Final Report

Evaluate Treatment Technologies for the Red Hill Drinking Water Well

Prepared For:
NAVFAC Hawaii
Pearl Harbor, Hawaii

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List of Acronyms and Abbreviations

3-D	Three Dimensional
AVGAS	Aviation Gasoline
AWWA	American Water Works Association
BAT	Best Available Technology
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
BWS	Board of Water Supply
CAS	Chemical Abstracts Service
CFR	Code of Federal Regulations
DCE	dichloroethane, dichloroethene
DOH	Department of Health
EAL	Environmental Action Level
EBCT	Empty Bed Contact Time
EPA	Environment Protection Agency
F-76	Diesel Marine Fuel
FISC	Fleet and Industrial Supply Center
FT, ft	Foot, Feet
GAC	Granular Activated Carbon
gpm	gallons per minute
GWAL	Groundwater Action Level
HAP	Hazardous Air Pollutant
HAR	Hawaii Administrative Rules
HBWS	Honolulu Board of Water Supply
HDOH	State of Hawaii, Department of Health
HP	Horsepower
JP-5	Jet Propulsion Fuel 5
JP-8	Jet Propulsion Fuel 8
LCCA	Lead Contamination Control Act
LNAPL	Light Non-Aqueous Phase Liquid
MAIC	Maximum Allowable Influent Concentration
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MEK	methyl ethyl ketone
MGD, mgd	Million Gallons per Day
MOGAS	Motor Gasoline
MSL	Mean Sea Level
MTBE	methyl tert-butyl ether
MW	Monitoring Well
NAVFAC	Naval Facility Engineering Command
ND	Navy Distillate
No., Nos	Number, Numbers
NPDWR	National Primary Drinking Water Regulations
NSDWR	National Secondary Drinking Water Regulations
NSFO	Navy Special Fuel Oil

List of Acronyms and Abbreviations

O&M	Operation and Maintenance
OMB	Office of Management and Budget
PAH	polynuclear aromatic hydrocarbon
PCE	perchloroethylene, tetrachloroethylene
P.L.	Public Law
ppm	parts per million
ppt	parts per thousand
PRV	Pressure Regulating Valve
PWC	Public Works Center
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SSRBL	Site Specific Risk Based Level
SVOC	Semi-Volatile Organic Compound
TCE	trichloroethylene
TPH	total petroleum hydrocarbons
TPH-DRO	total petroleum hydrocarbons in the diesel range organics
TPH-GRO	total petroleum hydrocarbons in the gasoline range organics
µg/L, µg/l	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
US, U.S.	United States
USA	Utility System Assessment
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbon

Executive Summary

Executive Summary

The Red Hill Well and Water Plant are located near Pearl Harbor on the island of Oahu. The water plant is owned, operated, and maintained by the Naval Facilities Engineering Command, Hawaii (NAVFAC Hawaii), and was constructed in 1942. It draws water from a submerged infiltration tunnel identified as U.S. Navy Well 2254-01. The design capacity of the Red Hill Well and Water Plant is 16 million gallons per day (mgd). However, under current operations, the majority of water supplied to the Pearl Harbor Complex is drawn from the Waiawa Water Plant. Water production from the Red Hill Well and Water Plant currently averages 3.0 to 3.5 mgd.

The Red Hill Well is located approximately 3,000 feet down-gradient from the U.S. Navy Red Hill Bulk Fuel Storage Facility. The fuel storage facility was constructed in the 1940s and includes 18 active and two inactive underground storage tanks. The primary fuel types stored at the facility include diesel oil, Navy Special Fuel Oil (NSFO), Navy Distillate (ND), Jet Propulsion Fuel 5 and 8 (JP-5 and JP-8), and F-76 (diesel marine fuel). In addition, Tank 17 contained Aviation Gasoline (AVGAS) and Motor Gasoline (MOGAS) between 1964 and 1969. Tank 18 contained AVGAS between 1964 and 1968. The tanks currently contain JP-5 fuel and F-76. Records indicated that several USTs were repaired and may have released petroleum to the environment. Previous environmental site investigations, which include data generated from four groundwater monitoring wells, indicated that a release has occurred and fuel has reached the groundwater underlying the fuel storage facility (TEC, 2008). The contaminants of concern for the Red Hill Well include volatile and semivolatile organic compounds associated with fuel.

The purpose of this study is to evaluate and identify feasible treatment technologies and treatment systems for removing potential contaminants of concern, and to ensure that the treated water from the Red Hill Water Plant continues to meet drinking water standards. The study also seeks to establish parameters for an event that would initiate programming and construction of the recommended water treatment facilities.

The United States Environmental Protection Agency (USEPA) has identified granular activated carbon (GAC) as the best available treatment technology for the majority of organic contaminants. The USEPA has identified GAC and air stripping as the best available treatment technologies for the removal of volatile organic compounds. The combination of air stripping and GAC treatment has been proven to prolong GAC bed life, and is generally considered to be more cost-effective than using GAC alone as the treatment technology. Therefore, the combination process of air-stripping followed by GAC treatment was established as the best available treatment technology for the Red Hill Well and Water Plant.

Due to the limited space within the Red Hill tunnel, three locations for a water treatment facility were identified: the Navy Halawa Reservoir site, the lower elevation end of the Red Hill Bulk Fuel Storage Facility, and the higher elevation end of the Red Hill Bulk Fuel Storage Facility. Three basic alternatives based on the three water treatment facility locations were developed. Two of the basic alternatives were further developed into sub-alternatives based on the configuration of pumps utilized to convey untreated water from the Red Hill Well to the treatment facility. The alternatives and sub-alternatives were evaluated on the basis of cost effectiveness, which included capital cost, annual operation and maintenance cost, and life cycle cost, and non-monetary factors that included impacts to existing facilities, complexity, and site considerations. A summary of the comparative evaluation is presented in Table ES-1.

Based on the available information, it is estimated that the following facilities would be required for Alternative 2a:

- Four 800 HP vertical turbine pumps.
- Two 30-inch pipelines between the Red Hill Water Plant and UST site, each approximately 4800 feet long.
- Water Treatment Facility:
    - One mechanical building;
    - Ten packed tower air strippers sized at 12 feet diameter by 42 feet high; each air stripper quipped with a blower with a 60 HP motor;
    - Three primary GAC and three secondary GAC contactor sized at approximately 24 feet wide by 48 feet long by 25 feet deep each;
    - Three underground clear well sized at approximately 20 feet wide by 20 feet long by 10 feet deep each;
    - Three pumping systems to pump water from the air stripping clear well to the primary GAC contactors; to pump water from the primary GAC clear well to the secondary GAC contactors; to pump water from the secondary GAC clear well to an on-site storage tank;
    - A 167,000-gallon potable water storage tank sized at roughly 34 feet diameter by 26 feet high.
    - AC driveway and parking lots
    - Chain link fence and gates.

It is also recommended that at least one additional monitoring well be constructed down-gradient from the Red Hill Bulk Fuel Storage facility, between RHMW01 and the Red Hill Well infiltration tunnel. The purpose of the well would be to provide additional data to assess whether the potential contaminants are migrating towards the Red Hill Well, whether attenuation of contaminant concentrations is occurring, and the net rate of contaminant migration towards the Red Hill Well.

Table ES-1
Summary of Comparative Evaluation of Treatment System Alternatives

Alternative	**Alternative 1**	**Alternative 2a**	**Alternative 2b**	**Alternative 3a**	**Alternative 3b**
Location	Navy Halawa Reservoir	Lower elevation side of Red Hill Bulk Fuel Storage Facility	Lower elevation side of Red Hill Bulk Fuel Storage Facility	Higher elevation side of Red Hill Bulk Fuel Storage Facility	Higher elevation side of Red Hill Bulk Fuel Storage Facility
General Description	Combination air-stripping and granular activated carbon treatment facility constructed. Existing well pumps utilized. Existing transmission and distribution system modified extensively.	Combination air-stripping and granular activated carbon treatment facility constructed. New well pumps utilized.	Combination air-stripping and granular activated carbon treatment facility constructed. Existing well pumps utilized with new in-line booster pumping system. Major electrical power system modifications required.	Combination air-stripping and granular activated carbon treatment facility constructed. Existing well pumps utilized with new in-line booster pumping system. Major electrical power system modifications required.	Combination air-stripping and granular activated carbon treatment facility constructed. Existing well pumps utilized with new in-line booster pumping system. Major electrical power system modifications required.
Life Cycle Cost	$243,533,946	$250,790,248	$263,053,587	$274,616,725	$277,377,699
Capital Cost	$41,000,000	$38,000,000	$44,000,000	$50,000,000	$51,000,000
Annual O&M Cost	$6,310,000	$6,700,000	$6,800,000	$7,010,000	$7,000,000
Degree of Impacts	High	Moderately	High	High	High
Complexity	High	Moderately Low	High	Moderately High	High
Site Considerations	Fair Near residential and public areas	Very Good Isolated from residen-tial and public areas	Very Good Isolated from residen-tial and public areas	Very Good Isolated from residen-tial and public areas	Very Good Isolated from residen-tial and public areas

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Chapter 1

Introduction and Background Information

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General

The Red Hill Water Plant is located near Pearl Harbor on the island of Oahu. The water plant is owned, operated, and maintained by the Naval Facilities Engineering Command, Hawaii (NAVFAC Hawaii), and was constructed in 1942. It draws water from a submerged infiltration tunnel, also known as an infiltration gallery, identified as U.S. Navy Well 2254-01. The design capacity of the Red Hill Water Plant is 16 million gallons per day (mgd), providing approximately 24 percent of the potable water supplied to the Pearl Harbor Complex Water System, which serves approximately 52,200 military consumers.

The Red Hill Water Plant is located approximately 3,000 feet down-gradient from the U.S. Navy Red Hill Bulk Fuel Storage Facility. The fuel storage facility has been used to store fuels since the facility was constructed in the 1940s. Previous environmental investigations indicated that petroleum releases to the ground underlying the fuel storage facility have occurred. The purpose of this study is to evaluate and identify feasible treatment technologies and treatment systems for removing potential contaminants of concern, and to ensure the treated water continues to meet drinking water standards.

Background Information

The U.S. Navy Red Hill Bulk Fuel Storage Facility is an operational facility that consists of 18 active and 2 inactive underground storage tanks located in the Moanalua area on Oahu, Hawaii as shown on Figure 1-1. The tanks were constructed of steel and each tank has a capacity of 12.5 million gallons. A series of tunnels and pipelines transmit fuel to and from Pearl Harbor Naval Base. The facility is located approximately 100 ft above the basal groundwater table.

According to Navy records, the USTs were constructed in the early 1940s. The upper domes of the tanks lie at depths varying between approximately 100 feet and 200 feet below the existing ground surface. The primary fuel types stored at the USTs include diesel oil, Navy Special Fuel Oil (NSFO), Navy Distillate (ND), Jet Propulsion Fuel 5 and 8 (JP-5 and JP-8), and F-76 (diesel marine fuel). In addition, Tank 17 contained Aviation Gasoline (AVGAS) and Motor Gasoline (MOGAS) between 1964 and 1969. Tank 18 contained AVGAS between 1964 and 1968. The tanks currently contain JP-5 fuel and F-76. Records indicated that several USTs were repaired and may have released petroleum to the environment. Previous environmental site investigations indicated that a release has occurred and fuel has reached the groundwater underlying the fuel storage facility (TEC, 2008).

Environmental investigations to assess potential release from the USTs have been conducted since 1998. In February 2001, the Navy constructed a monitoring well, RHMW01, into the basal aquifer, directly down-gradient from the fuel storage facility, within the lower access tunnel of the facility. Groundwater samples from RHMW01 indicated that petroleum had been released from several USTs (AMEC, 2002). To protect the down-gradient drinking water resource associated with the U.S. Navy Well 2254-01, the U.S Navy constructed four additional

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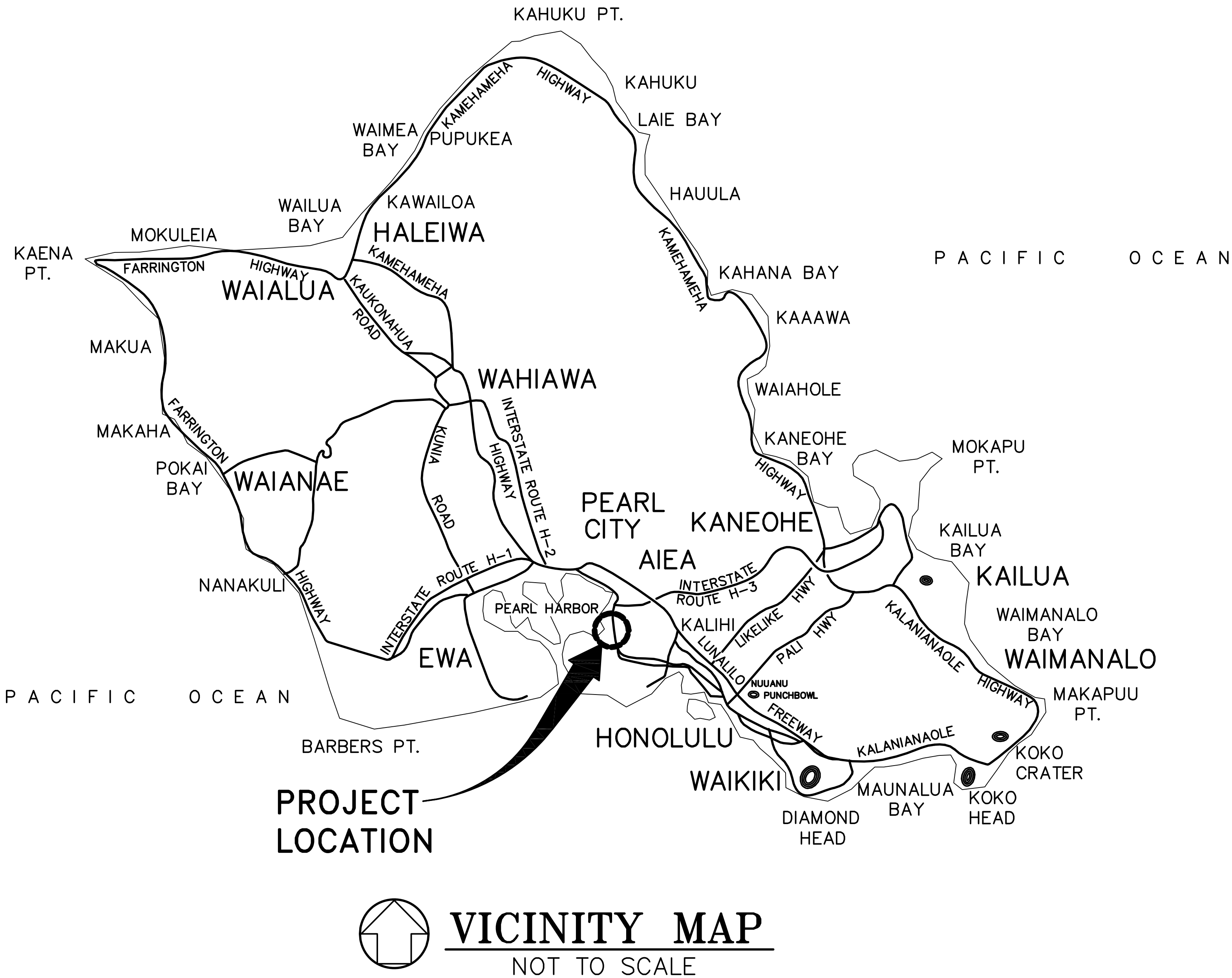

VICINITY MAP

NOT TO SCALE

HDR HPE Hawaii Pacific Engineers, Inc.	EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII PEARL HARBOR OAHU, HAWAII	VICINITY MAP	FIGURE 1–1

groundwater monitoring wells between 2002 and 2005. Monitoring wells RHMW02 and RHMW03 were constructed within the facility lower access tunnel. A background monitoring well, RHWM04, was constructed up-gradient from the facility adjacent to the U.S. Navy Firing Range. The fifth groundwater monitoring well, RHMW2254-01, was constructed within the U.S. Navy Well 2254-01 infiltration gallery. The general locations of the Red Hill Well U.S. Navy Well 2254-01 and the Red Hill Monitoring Wells are shown on Figure 1-2.

As part of a comprehensive environmental investigation and risk assessment, quarterly groundwater sampling has been conducted since 2005. Groundwater samples were analyzed for petroleum constituents and compared against the State of Hawaii Department of Health (HDOH) Environmental Action Levels (EALs). A copy of EALs for groundwater established by HDOH is included in Appendix A. For a conservative approach, HDOH EALs were adopted as the final ground water action level for the quarterly groundwater sampling study. In addition to the environmental site investigations, a three-dimensional (3-D) groundwater model was developed for the Red Hill UST site to produce site-specific risk-based levels (SSRBLs) for compounds of concerns (TEC 2008). The HDOH EALs and SSRBLs are summarized in Table 1-1.

Table 1-1
HDOH EALs and SSRBLs Summary

Chemical	**HDOH EAL µg/L**	**SSRBL µg/L**
Volatiles		
Benzene	5	750
Ethylbenzene	700	NA
Methyl Tert Butyl Ether	10.59	NA
Toluene	1,000	NA
Xylenes	10,000	NA
Semi-volatiles		
Acenaphthene	365	NA
Benzo(a)pyrene	0.2	NA
Fluoranthene	1,460	NA
Naphthalene	6.22	NA
Lead		
Total	not established	not established
Dissolved	15	NA
Other		
Total Petroleum Hydrocarbon	100	4,500

Notes:
1. NA: Not applicable or not determined
2. EALs are applicable at U.S. Navy Well 2254-01
3. SSRBLs are applicable at RHMW01, RHMW02, and RHMW03
4. Source: Final Red Hill Bulk Fuel Storage Facility Groundwater Protection Plan, January 2008, TEC Inc

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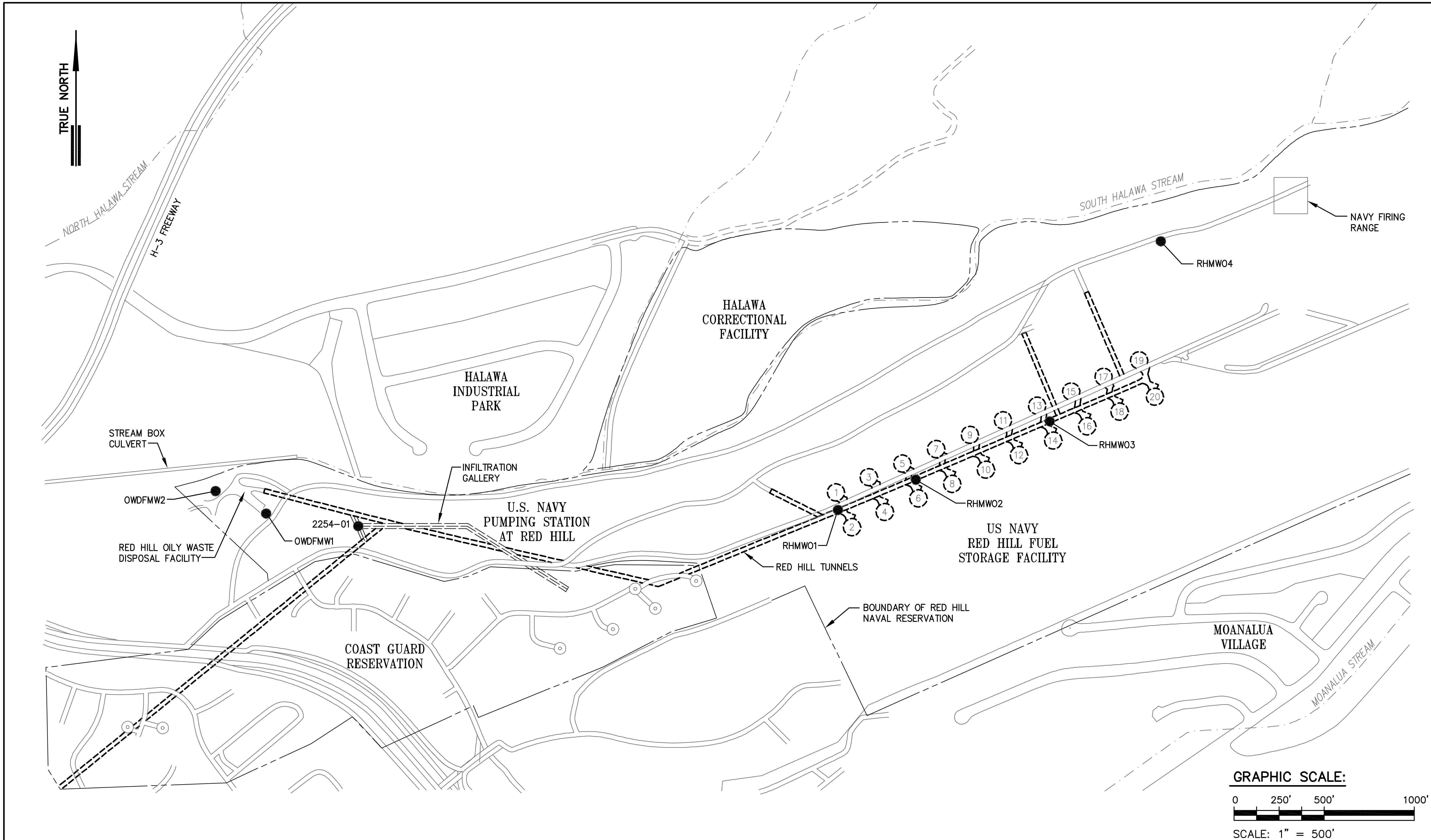

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EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII

PEARL HARBOR | OAHU, HAWAII

GENERAL LOCATION MAP

FIGURE 1–2

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Based on the results of previous environmental investigations and risk assessments, the following environmental conditions for the Red Hill groundwater were documented.

- Groundwater samples from RHMW01 indicated that petroleum from the fuel storage facility had migrated to the basal aquifer (AMEC, 2002).

- U.S. Navy began quarterly monitoring of the aquifer in 2005. Total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs) and lead have been detected in the groundwater beneath the fuel storage facility.

- At RHMW01, concentrations of TPH quantified as Diesel-Range Organics (TPH-DRO) have exceeded the HDOH EAL since September 2005 but are less than 25 percent of the SSRBL of 4500 µg/L. Since March 2008, TPH-DRO increased in concentration following a decreasing trend over the previous rounds as indicated in Table 1-2.

- At RHMW02, concentrations of TPH-DRO have exceeded the HDOH EAL since September 2005 and greater than 50 percent of the SSRBL of 4500 µg/L. The concentrations of TPH-DRO remained relatively constant but showed an increasing trend since January 2008. The average concentration from the October 2008 samples was greater than the SSRBL. The TPH-DRO concentrations have exceeded the HDOH EAL for the three rounds between July 2006 and May 2007. Three PAHs, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene) have exceeded HDOH EALs since September 2005. The three PAH concentrations fluctuated in the previous rounds and showed a decreasing trend in October 2008. One VOC, naphthalene, exceeded the HDOH EAL in September 2005. The analytical results are presented in Table 1-3.

- At RHMW03, concentrations of TPH-DRO have fluctuated around the HDOH EAL since September 2005, and are significantly lower than the levels in RHMW01 and RHMW02. The concentrations of TPH-DRO showed an increasing trend over the past three rounds, since April 2008 as indicated in Table 1-4.

- At RHMW04, groundwater sampling was only conducted in September 2005 and July 2006. In September 2005, concentrations of TPH-DRO and four PAHs benzo(a)anthracene, benzo(a)phrene, benzo(g,h,i)perylene, and dibenzo(a,h)anthtracene, exceeded the HDOH EAL. In July 2006, none of the contaminants was detected in the groundwater samples as indicated in Table 1-5.

- At RHMW2254-01, the TPH-DRO concentration in March 2008 exceeded the HDOH EAL as indicated in Table 1-6.

- The results of the 3-D groundwater model indicated that JP-5 fuel presented the biggest risk to the U.S. Navy water supply, due to its mobility and toxicity.

- The 3-D groundwater model result also indicated that a non-aqueous plume of JP-5 free product must migrate to within 1,100 feet of the U.S. Navy Well 2254-01 infiltration gallery for the HDOH EALs to be exceeded at the U.S. Navy Well 2254-01 (TEC 2007) .

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Table 1-2
Quarterly Ground Water Monitoring - Well RHMW01

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Petroleum														
TPH (middle distillates)	-	-	1.00E-01	-	N/A	5.09E-01	3.03E-01	3.07E-01	2.74E-01	2.61E-01	5.74E-01	4.27E-01	3.27E-01	4.59E-01
TPH (gasolines)	-	-	1.00E-01	-	N/A	ND	ND	ND	ND	ND	ND	1.36E-02	ND	ND
PAH (Semi-Volatile)														
Acenaphthene	83-32-9	3.90E+00	2.00E-02	-	N/A	ND	ND	ND	ND	ND	3.10E-05	4.06E-05	ND	ND
Acenaphthylene	208-96-8	1.61E+01	2.40E-01	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Anthracene	120-12-7	4.34E-02	7.30E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(a)Anthracene	56-55-3	9.40E-03	2.70E-05	-	N/A	-	-	-	-	-	-	-	-	-
Benzo(a)Pyrene	50-32-8	1.62E-03	1.40E-05	2.00E-04	N/A	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)Fluoranthene	205-99-2	1.50E-03	9.20E-05	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)Perylene	191-24-2	2.60E-04	1.00E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(k)Fluoranthene	207-08-9	8.00E-04	4.00E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Chrysene	218-01-9	2.00E-03	3.50E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	9.20E-06	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	206-44-0	2.60E-01	4.00E-02	-	N/A	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	86-73-7	1.69E+00	2.40E-01	-	N/A	-	-	ND	ND	ND	3.71E-05	3.75E-05	2.06E-05	2.00E-05
Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	9.20E-05	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	-	-	-	-	-	-	-	-	-	-	ND	-
Methylnaphthalene, 1-	90-12-0	2.58E+01	4.70E-03	-	N/A	-	-	ND	ND	ND	6.40E-05	1.01E-04	ND	ND
Methylnaphthalene, 2-	91-57-6	2.46E+01	1.00E-02	-	N/A	-	-	ND	ND	ND	4.78E-05	7.89E-05	ND	ND
Naphthalene	75-34-3	3.10E+01	1.70E-02	-	N/A	ND	ND	ND	ND	ND	2.10E-04	2.16E-04	1.14E-04	1.00E-04
Phenanthrene	85-01-8	1.15E+00	7.70E-03	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
Pyrene	129-00-0	1.35E-01	2.00E-03	-	N/A	-	-	ND	ND	ND	ND	ND	ND	ND
VOC														
Acetone	67-64-1	1.00E+06	1.50E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Benzene	71-43-2	1.79E+03	5.00E-03	5.00E-03	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	75-27-4	3.03E+03	2.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromoform	75-25-2	3.10E+03	1.00E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromomethane	74-83-9	1.52E+04	8.70E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	56-23-5	7.93E+02	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	108-90-7	4.98E+02	5.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroethane	75-00-3	6.71E+03	3.90E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroform	67-66-3	7.95E+03	7.00E-02	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloromethane	74-87-3	5.32E+03	1.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromo, 1,2- Chloropropane, 3-	96-12-8	1.23E+03	4.00E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	74-95-3	1.19E+04	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,3-	541-73-1	1.25E+02	1.80E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,4-	106-46-7	8.13E+01	5.00E-03	7.50E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethene, Trans 1,2-	156-60-5	4.52E+03	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethyene, 1,1-	75-35-4	2.42E+03	7.00E-03	7.00E-03	-	ND	ND	-	-	-	-	-	-	-
Dichloroethylene, Cis 1,2-	156-59-2	6.41E+03	7.00E-02	7.00E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,2-	78-87-5	2.80E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,3-	142-28-9	2.75E+03	4.30E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	100-41-4	1.69E+02	3.00E-02	7.00E-01	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorbutadiene	87-68-3	3.20E+00	8.60E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Ethyl Ketone	78-93-3	2.23E-05	7.10E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND

Table 1-2
Quarterly Ground Water Monitoring - Well RHMW01

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Methyl Isobutyl Ketone	108-10-1	1.90E+04	1.70E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.00E-03	-	5.00E-04	ND	ND	-	-	-	-	-	-	-
Methylene Chloride	75-09-2	1.30E+04	4.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
m-Xylene	108-38-3	1.61E+02	-	-	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	91-20-3	3.10E+01	1.70E-02	-	-	ND	ND	ND	ND	ND	5.98E-03	ND	ND	ND
o-Xylene	95-47-6	1.78E+02	-	-	5.00E-04	ND	ND	-	-	-	-	-	-	-
p-Xylene	106-42-3	1.62E+02	-	-	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	100-42-5	3.10E+02	1.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,1,2-	630-20-6	1.07E+03	5.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,2,2-	79-34-5	2.83E+03	6.70E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	127-18-4	2.06E+02	5.00E-03	5.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	108-88-3	5.26E+02	4.00E-02	1.00E+00	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	7.00E-02	7.00E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Trichloroethane, 1,1,1-	71-55-6	1.29E+03	2.00E-01	2.00E-01	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethane, 1,1,2-	79-00-5	4.59E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	79-01-6	1.28E+03	5.00E-03	5.00E-03	5.00E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	75-01-4	8.80E+03	2.00E-03	2.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead														
Lead	7439-92-1	-	1.50E-02	1.50E-02	-	ND	1.70E-03	1.70E-03	ND	ND	ND	ND	ND	9.70E-04

Legend:
- Contaminant exceeds HDOH EALs.
- N/A - Not Applicable
- "-" = Chemical was not tested.
- ND = Chemical not detected.

Source:
1 Chemical Results, September 2005
2 Chemical Results, July 2006
3 Chemical Results, December 2006
4 Chemical Results, May 2007
5 Chemical Results, June 2007
6 Chemical Results, September 2007
7 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, March 2008
8 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, May 2008
9 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, October 2008
10 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, February 2009
11 United States National Library of Medicine, National Institute of Health. http://www.nlm.nih.gov/
12 Hawaii Department of Health. Environmental Action Levels. Table D-1b.
13 Environmetal Protection Agency. Contaminant MCLs.

Table 1-3
Quarterly Ground Water Monitoring - Well RHMW02

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Petroleum														
TPH (middle distillates)	-	-	1.00E-01	-	2.66E+00	2.80E+00	2.60E+00	2.75E+00	2.75E+00	2.81E+00	2.31E+00	3.12E+00	4.47E+00	4.54E+00
TPH (gasolines)	-	-	1.00E-01	-	5.00E-02	1.24E-01	1.10E-01	1.22E-01	5.25E-02	7.60E-02	6.43E-02	5.89E-02	6.17E-02	5.28E-02
PAH (Semi-Volatile)														
Acenaphthene	83-32-9	3.90E+00	2.00E-02	-	5.20E-04	6.30E-04	5.30E-04	6.60E-04	ND	6.00E-04	3.08E-04	4.04E-04	4.70E-04	3.70E-04
Acenaphthylene	208-96-8	1.61E+01	2.40E-01	-	5.20E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Anthracene	120-12-7	4.34E-02	7.30E-04	-	5.20E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(a)Anthracene	56-55-3	9.40E-03	2.70E-05	-	5.20E-05	-	-	-	-	-	-	-	-	-
Benzo(a)Pyrene	50-32-8	1.62E-03	1.40E-05	2.00E-04	1.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)Fluoranthene	205-99-2	1.50E-03	9.20E-05	-	5.20E-05	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)Perylene	191-24-2	2.60E-04	1.00E-04	-	1.00E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(k)Fluoranthene	207-08-9	8.00E-04	4.00E-04	-	1.00E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Chrysene	218-01-9	2.00E-03	3.50E-04	-	1.00E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	9.20E-06	-	5.20E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	206-44-0	2.60E-01	4.00E-02	-	2.60E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	86-73-7	1.69E+00	2.40E-01	-	2.60E-04	-	-	2.60E-04	3.10E-04	3.90E-04	1.61E-04	2.20E-04	3.24E-04	2.10E-04
Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	9.20E-05	-	5.20E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	-	-	-	-	-	-	-	-	-	-	1.34E-01	-
Methylnaphthalene, 1-	90-12-0	2.58E+01	4.70E-03	-	1.04E-01	-	-	7.21E-02	6.73E-02	1.09E-01	6.70E-02	7.58E-02	1.02E-01	7.21E-02
Methylnaphthalene, 2-	91-57-6	2.46E+01	1.00E-02	-	8.85E-02	-	-	3.03E-02	2.65E-02	2.15E-02	2.38E-02	3.45E-02	3.15E-02	1.37E-02
Naphthalene	75-34-3	3.10E+01	1.70E-02	-	1.20E-01	1.71E-01	1.60E-01	1.05E-01	8.72E-02	1.44E-01	9.36E-02	7.30E-02	1.40E-01	9.74E-02
Phenanthrene	85-01-8	1.15E+00	7.70E-03	-	5.20E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Pyrene	129-00-0	1.35E-01	2.00E-03	-	2.60E-04	-	-	ND	ND	ND	ND	ND	ND	ND
VOC														
Acetone	67-64-1	1.00E+06	1.50E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Benzene	71-43-2	1.79E+03	5.00E-03	5.00E-03	2.50E-03	ND	ND	ND	ND	ND	1.70E-04	ND	ND	1.40E-04
Bromodichloromethane	75-27-4	3.03E+03	2.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromoform	75-25-2	3.10E+03	1.00E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromomethane	74-83-9	1.52E+04	8.70E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	56-23-5	7.93E+02	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	108-90-7	4.98E+02	5.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroethane	75-00-3	6.71E+03	3.90E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroform	67-66-3	7.95E+03	7.00E-02	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloromethane	74-87-3	5.32E+03	1.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromo, 1,2- Chloropropane, 3-	96-12-8	1.23E+03	4.00E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	74-95-3	1.19E+04	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,3-	541-73-1	1.25E+02	1.80E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,4-	106-46-7	8.13E+01	5.00E-03	7.50E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethene, Trans 1,2-	156-60-5	4.52E+03	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethyene, 1,1-	75-35-4	2.42E+03	7.00E-03	7.00E-03	-	ND	ND	-	-	-	-	-	-	-
Dichloroethylene, Cis 1,2-	156-59-2	6.41E+03	7.00E-02	7.00E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,2-	78-87-5	2.80E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,3-	142-28-9	2.75E+03	4.30E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	100-41-4	1.69E+02	3.00E-02	7.00E-01	2.50E-03	1.30E-03	1.20E-03	ND	ND	ND	ND	ND	5.80E-04	4.50E-04
Hexachlorbutadiene	87-68-3	3.20E+00	8.60E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Ethyl Ketone	78-93-3	2.23E-05	7.10E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND

Table 1-3
Quarterly Ground Water Monitoring - Well RHMW02

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Methyl Isobutyl Ketone	108-10-1	1.90E+04	1.70E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.00E-03	-	2.50E-03	ND	ND	-	-	-	-	-	-	-
Methylene Chloride	75-09-2	1.30E+04	4.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
m-Xylene	108-38-3	1.61E+02	-	-	2.50E-03	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	91-20-3	3.10E+01	1.70E-02	-	-	3.43E-01	2.57E-01	1.96E-01	2.09E-01	2.06E-01	1.95E-01	2.90E-01	3.20E-01	2.39E-01
o-Xylene	95-47-6	1.78E+02	-	-	2.50E-03	ND	ND	-	-	-	-	-	-	-
p-Xylene	106-42-3	1.62E+02	-	-	2.50E-03	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	100-42-5	3.10E+02	1.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,1,2-	630-20-6	1.07E+03	5.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,2,2-	79-34-5	2.83E+03	6.70E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	127-18-4	2.06E+02	5.00E-03	5.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	108-88-3	5.26E+02	4.00E-02	1.00E+00	2.50E-03	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	7.00E-02	7.00E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Trichloroethane, 1,1,1-	71-55-6	1.29E+03	2.00E-01	2.00E-01	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethane, 1,1,2-	79-00-5	4.59E+03	5.00E-03	5.00E-03	8.20E-03	-	-	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	79-01-6	1.28E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	75-01-4	8.80E+03	2.00E-03	2.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead														
Lead	7439-92-1	-	1.50E-02	1.50E-02	-	ND	1.70E-03	1.70E-03	ND	ND	ND	ND	ND	9.70E-04

Legend:
Contaminant exceeds HDOH EALs.
N/A - Not Applicable
"-" = Chemical was not tested.
ND = Chemical not detected.

Source:
1 Chemical Results, September 2005
2 Chemical Results, July 2006
3 Chemical Results, December 2006
4 Chemical Results, May 2007
5 Chemical Results, June 2007
6 Chemical Results, September 2007
7 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, March 2008
8 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, May 2008
9 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, October 2008
10 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, February 2009
11 United States National Library of Medicine, National Institute of Health. http://www.nlm.nih.gov/
12 Hawaii Department of Health. Environmental Action Levels. Table D-1b.
13 Environmetal Protection Agency. Contaminant MCLs.

Table 1-4
Quarterly Ground Water Monitoring - Well RHMW03

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Petroleum														
TPH (middle distillates)	-	-	1.00E-01	-	5.00E-02	1.42E-01	ND	9.57E-02	1.23E-01	ND	2.42E-01	1.90E-01	1.99E-01	2.44E-01
TPH (gasolines)	-	-	1.00E-01	-	1.62E-01	ND	ND	ND	ND	ND	ND	ND	ND	ND
PAH (Semi-Volatile)														
Acenaphthene	83-32-9	3.90E+00	2.00E-02	-	4.80E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	208-96-8	1.61E+01	2.40E-01	-	4.80E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Anthracene	120-12-7	4.34E-02	7.30E-04	-	4.80E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(a)Anthracene	56-55-3	9.40E-03	2.70E-05	-	4.80E-05	-	-	-	-	-	-	-	-	-
Benzo(a)Pyrene	50-32-8	1.62E-03	1.40E-05	2.00E-04	9.60E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)Fluoranthene	205-99-2	1.50E-03	9.20E-05	-	4.80E-05	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)Perylene	191-24-2	2.60E-04	1.00E-04	-	9.60E-05	-	-	ND	ND	ND	ND	ND	ND	ND
Benzo(k)Fluoranthene	207-08-9	8.00E-04	4.00E-04	-	9.60E-05	-	-	ND	ND	ND	ND	ND	ND	ND
Chrysene	218-01-9	2.00E-03	3.50E-04	-	9.60E-05	-	-	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	9.20E-06	-	4.80E-05	-	-	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	206-44-0	2.60E-01	4.00E-02	-	2.40E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	86-73-7	1.69E+00	2.40E-01	-	2.40E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	9.20E-05	-	4.80E-05	-	-	ND	ND	ND	ND	ND	ND	ND
Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	-	-	-	-	-	-	-	-	-	-	2.94E-05	-
Methylnaphthalene, 1-	90-12-0	2.58E+01	4.70E-03	-	2.40E-04	-	-	ND	ND	ND	ND	2.68E-05	2.94E-05	7.00E-05
Methylnaphthalene, 2-	91-57-6	2.46E+01	1.00E-02	-	2.40E-04	-	-	ND	ND	ND	ND	2.79E-05	ND	9.00E-05
Naphthalene	75-34-3	3.10E+01	1.70E-02	-	2.40E-04	ND	ND	ND	ND	ND	ND	ND	6.89E-05	2.20E-04
Phenanthrene	85-01-8	1.15E+00	7.70E-03	-	4.80E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Pyrene	129-00-0	1.35E-01	2.00E-03	-	2.40E-04	-	-	ND	ND	ND	ND	ND	ND	ND
VOC														
Acetone	67-64-1	1.00E+06	1.50E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Benzene	71-43-2	1.79E+03	5.00E-03	5.00E-03	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	75-27-4	3.03E+03	2.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromoform	75-25-2	3.10E+03	1.00E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromomethane	74-83-9	1.52E+04	8.70E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	56-23-5	7.93E+02	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	108-90-7	4.98E+02	5.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroethane	75-00-3	6.71E+03	3.90E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroform	67-66-3	7.95E+03	7.00E-02	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloromethane	74-87-3	5.32E+03	1.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromo, 1,2- Chloropropane, 3-	96-12-8	1.23E+03	4.00E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	74-95-3	1.19E+04	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,3-	541-73-1	1.25E+02	1.80E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,4-	106-46-7	8.13E+01	5.00E-03	7.50E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethene, Trans 1,2-	156-60-5	4.52E+03	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethyene, 1,1-	75-35-4	2.42E+03	7.00E-03	7.00E-03	-	ND	ND	-	-	-	-	-	-	-
Dichloroethylene, Cis 1,2-	156-59-2	6.41E+03	7.00E-02	7.00E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,2-	78-87-5	2.80E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,3-	142-28-9	2.75E+03	4.30E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	100-41-4	1.69E+02	3.00E-02	7.00E-01	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorbutadiene	87-68-3	3.20E+00	8.60E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Ethyl Ketone	78-93-3	2.23E-05	7.10E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND

Table 1-4
Quarterly Ground Water Monitoring - Well RHMW03

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Methyl Isobutyl Ketone	108-10-1	1.90E+04	1.70E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.00E-03	-	5.00E-04	ND	ND	-	-	-	-	-	-	-
Methylene Chloride	75-09-2	1.30E+04	4.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
m-Xylene	108-38-3	1.61E+02	-	-	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	91-20-3	3.10E+01	1.70E-02	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	95-47-6	1.78E+02	-	-	5.00E-04	ND	ND	-	-	-	-	-	-	-
p-Xylene	106-42-3	1.62E+02	-	-	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	100-42-5	3.10E+02	1.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,1,2-	630-20-6	1.07E+03	5.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,2,2-	79-34-5	2.83E+03	6.70E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	127-18-4	2.06E+02	5.00E-03	5.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	108-88-3	5.26E+02	4.00E-02	1.00E+00	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	7.00E-02	7.00E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Trichloroethane, 1,1,1-	71-55-6	1.29E+03	2.00E-01	2.00E-01	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethane, 1,1,2-	79-00-5	4.59E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	79-01-6	1.28E+03	5.00E-03	5.00E-03	5.00E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	75-01-4	8.80E+03	2.00E-03	2.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead														
Lead	7439-92-1	-	1.50E-02	1.50E-02	-	ND	1.70E-03	3.00E-03	ND	ND	ND	ND	ND	ND

Legend:
Contaminant exceeds HDOH EALs.
N/A - Not Applicable
"-" = Chemical was not tested.
ND = Chemical not detected.

Source:
1 Chemical Results, September 2005
2 Chemical Results, July 2006
3 Chemical Results, December 2006
4 Chemical Results, May 2007
5 Chemical Results, June 2007
6 Chemical Results, September 2007
7 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, March 2008
8 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, May 2008
9 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, October 2008
10 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, February 2009
11 United States National Library of Medicine, National Institute of Health. http://www.nlm.nih.gov/
12 Hawaii Department of Health. Environmental Action Levels. Table D-1b.
13 Environmetal Protection Agency. Contaminant MCLs.

Table 1-5
Quarterly Ground Water Monitoring - Well RHMW04

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Petroleum														
TPH (middle distillates)	-	-	1.00E-01	-	3.38E-01	ND	-	-	-	-	-	-	-	-
TPH (gasolines)	-	-	1.00E-01	-	5.00E-02	ND	-	-	-	-	-	-	-	-
PAH (Semi-Volatile)														
Acenaphthene	83-32-9	3.90E+00	2.00E-02	-	5.70E-04	ND	-	-	-	-	-	-	-	-
Acenaphthylene	208-96-8	1.61E+01	2.40E-01	-	5.70E-04	-	-	-	-	-	-	-	-	-
Anthracene	120-12-7	4.34E-02	7.30E-04	-	5.70E-04	-	-	-	-	-	-	-	-	-
Benzo(a)Anthracene	56-55-3	9.40E-03	2.70E-05	-	5.70E-05	-	-	-	-	-	-	-	-	-
Benzo(a)Pyrene	50-32-8	1.62E-03	1.40E-05	2.00E-04	1.10E-04	ND	-	-	-	-	-	-	-	-
Benzo(b)Fluoranthene	205-99-2	1.50E-03	9.20E-05	-	5.70E-05	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)Perylene	191-24-2	2.60E-04	1.00E-04	-	1.10E-04	-	-	-	-	-	-	-	-	-
Benzo(k)Fluoranthene	207-08-9	8.00E-04	4.00E-04	-	1.10E-04	-	-	-	-	-	-	-	-	-
Chrysene	218-01-9	2.00E-03	3.50E-04	-	1.10E-04	-	-	-	-	-	-	-	-	-
Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	9.20E-06	-	5.70E-05	-	-	-	-	-	-	-	-	-
Fluoranthene	206-44-0	2.60E-01	4.00E-02	-	2.80E-04	ND	-	-	-	-	-	-	-	-
Fluorene	86-73-7	1.69E+00	2.40E-01	-	2.80E-04	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	9.20E-05	-	5.70E-05	-	-	-	-	-	-	-	-	-
Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 1-	90-12-0	2.58E+01	4.70E-03	-	2.80E-04	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	91-57-6	2.46E+01	1.00E-02	-	2.80E-04	-	-	-	-	-	-	-	-	-
Naphthalene	75-34-3	3.10E+01	1.70E-02	-	2.80E-04	ND	-	-	-	-	-	-	-	-
Phenanthrene	85-01-8	1.15E+00	7.70E-03	-	5.70E-04	-	-	-	-	-	-	-	-	-
Pyrene	129-00-0	1.35E-01	2.00E-03	-	2.80E-04	-	-	-	-	-	-	-	-	-
VOC														
Acetone	67-64-1	1.00E+06	1.50E+00	-	-	-	-	-	-	-	-	-	-	-
Benzene	71-43-2	1.79E+03	5.00E-03	5.00E-03	5.00E-04	ND	-	-	-	-	-	-	-	-
Bromodichloromethane	75-27-4	3.03E+03	-	-	-	-	-	-	-	-	-	-	-	-
Bromoform	75-25-2	3.10E+03	1.00E-01	-	-	-	-	-	-	-	-	-	-	-
Bromomethane	74-83-9	1.52E+04	8.70E-03	-	-	-	-	-	-	-	-	-	-	-
Carbon Tetrachloride	56-23-5	7.93E+02	5.00E-03	5.00E-03	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	108-90-7	4.98E+02	5.00E-02	1.00E-01	-	-	-	-	-	-	-	-	-	-
Chloroethane	75-00-3	6.71E+03	3.90E-03	-	-	-	-	-	-	-	-	-	-	-
Chloroform	67-66-3	7.95E+03	7.00E-02	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	74-87-3	5.32E+03	1.80E-03	-	-	-	-	-	-	-	-	-	-	-
Dibromo, 1,2- Chloropropane, 3-	96-12-8	1.23E+03	4.00E-05	-	-	-	-	-	-	-	-	-	-	-
Dibromomethane	74-95-3	1.19E+04	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorobenzene, 1,3-	541-73-1	1.25E+02	1.80E-01	-	-	-	-	-	-	-	-	-	-	-
Dichlorobenzene, 1,4-	106-46-7	8.13E+01	5.00E-03	7.50E-02	-	-	-	-	-	-	-	-	-	-
Dichloroethene, Trans 1,2-	156-60-5	4.52E+03	-	-	-	-	-	-	-	-	-	-	-	-
Dichloroethyene, 1,1-	75-35-4	2.42E+03	7.00E-03	7.00E-03	-	ND	-	-	-	-	-	-	-	-
Dichloroethylene, Cis 1,2-	156-59-2	6.41E+03	7.00E-02	7.00E-02	-	-	-	-	-	-	-	-	-	-
Dichloropropane, 1,2-	78-87-5	2.80E+03	5.00E-03	5.00E-03	-	-	-	-	-	-	-	-	-	-
Dichloropropane, 1,3-	142-28-9	2.75E+03	4.30E-04	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	100-41-4	1.69E+02	3.00E-02	7.00E-01	5.00E-04	ND	-	-	-	-	-	-	-	-
Hexachlorbutadiene	87-68-3	3.20E+00	8.60E-04	-	-	-	-	-	-	-	-	-	-	-
Methyl Ethyl Ketone	78-93-3	2.23E-05	7.10E+00	-	-	-	-	-	-	-	-	-	-	-

Table 1-5
Quarterly Ground Water Monitoring - Well RHMW04

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Methyl Isobutyl Ketone	108-10-1	1.90E+04	1.70E-01	-	-	-	-	-	-	-	-	-	-	-
Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.00E-03	-	5.00E-04	ND	-	-	-	-	-	-	-	-
Methylene Chloride	75-09-2	1.30E+04	4.80E-03	-	-	-	-	-	-	-	-	-	-	-
m-Xylene	108-38-3	1.61E+02	-	-	5.00E-04	ND	-	-	-	-	-	-	-	-
Naphthalene	91-20-3	3.10E+01	1.70E-02	-	-	ND	-	-	-	-	-	-	-	-
o-Xylene	95-47-6	1.78E+02	-	-	5.00E-04	ND	-	-	-	-	-	-	-	-
p-Xylene	106-42-3	1.62E+02	-	-	5.00E-04	ND	-	-	-	-	-	-	-	-
Styrene	100-42-5	3.10E+02	1.00E-02	1.00E-01	-	-	-	-	-	-	-	-	-	-
Tetrachloroethane, 1,1,1,2-	630-20-6	1.07E+03	5.20E-04	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethane, 1,1,2,2-	79-34-5	2.83E+03	6.70E-05	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	127-18-4	2.06E+02	5.00E-03	5.00E-03	-	ND	-	-	-	-	-	-	-	-
Toluene	108-88-3	5.26E+02	4.00E-02	1.00E+00	5.00E-04	ND	-	-	-	-	-	-	-	-
Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	7.00E-02	7.00E-02	-	-	-	-	-	-	-	-	-	-
Trichloroethane, 1,1,1-	71-55-6	1.29E+03	2.00E-01	2.00E-01	-	ND	-	-	-	-	-	-	-	-
Trichloroethane, 1,1,2-	79-00-5	4.59E+03	5.00E-03	5.00E-03	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	79-01-6	1.28E+03	5.00E-03	5.00E-03	5.00E-04	-	-	-	-	-	-	-	-	-
Vinyl Chloride	75-01-4	8.80E+03	2.00E-03	2.00E-03	-	ND	-	-	-	-	-	-	-	-
Lead														
Lead	7439-92-1	-	1.50E-02	1.50E-02	-	ND	-	-	-	-	-	-	-	-

Legend:
Contaminant exceeds HDOH EALs.
N/A - Not Applicable
"-" = Chemical was not tested.
ND = Chemical not detected.

Source:
1 Chemical Results, September 2005
2 Chemical Results, July 2006
3 Chemical Results, December 2006
4 Chemical Results, May 2007
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8 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, May 2008
9 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, October 2008
10 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, February 2009
11 United States National Library of Medicine, National Institute of Health. http://www.nlm.nih.gov/
12 Hawaii Department of Health. Environmental Action Levels. Table D-1b.
13 Environmetal Protection Agency. Contaminant MCLs.

Table 1-6
Quarterly Ground Water Monitoring - Well RHMW2254

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Petroleum														
TPH (middle distillates)	-	-	1.00E-01	-	-	ND	ND	ND	ND	ND	1.02E-01	ND	ND	-
TPH (gasolines)	-	-	1.00E-01	-	-	ND	ND	ND	ND	ND	ND	ND	ND	-
PAH (Semi-Volatile)														
Acenaphthene	83-32-9	3.90E+00	2.00E-02	-	N/A	ND	ND	ND	ND	ND	ND	ND	ND	-
Acenaphthylene	208-96-8	1.61E+01	2.40E-01	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Anthracene	120-12-7	4.34E-02	7.30E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Benzo(a)Anthracene	56-55-3	9.40E-03	2.70E-05	-	N/A	-	-	-	-	-	-	-	-	-
Benzo(a)Pyrene	50-32-8	1.62E-03	1.40E-05	2.00E-04	N/A	ND	ND	ND	ND	ND	ND	ND	ND	-
Benzo(b)Fluoranthene	205-99-2	1.50E-03	9.20E-05	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Benzo(g,h,i)Perylene	191-24-2	2.60E-04	1.00E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Benzo(k)Fluoranthene	207-08-9	8.00E-04	4.00E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Chrysene	218-01-9	2.00E-03	3.50E-04	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	9.20E-06	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Fluoranthene	206-44-0	2.60E-01	4.00E-02	-	N/A	ND	ND	ND	ND	ND	ND	ND	ND	-
Fluorene	86-73-7	1.69E+00	2.40E-01	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	9.20E-05	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 1-	90-12-0	2.58E+01	4.70E-03	-	N/A	-	-	ND	ND	ND	ND	4.35E-05	ND	-
Methylnaphthalene, 2-	91-57-6	2.46E+01	1.00E-02	-	N/A	-	-	ND	ND	ND	ND	5.61E-05	ND	-
Naphthalene	75-34-3	3.10E+01	1.70E-02	-	N/A	ND	ND	ND	ND	ND	ND	ND	ND	-
Phenanthrene	85-01-8	1.15E+00	7.70E-03	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
Pyrene	129-00-0	1.35E-01	2.00E-03	-	N/A	-	-	ND	ND	ND	ND	ND	ND	-
VOC														
Acetone	67-64-1	1.00E+06	1.50E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Benzene	71-43-2	1.79E+03	5.00E-03	5.00E-03	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	75-27-4	3.03E+03	2.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromoform	75-25-2	3.10E+03	1.00E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Bromomethane	74-83-9	1.52E+04	8.70E-03	-	-	-	-	ND	ND	ND	ND	ND	1.26E-03	ND
Carbon Tetrachloride	56-23-5	7.93E+02	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	108-90-7	4.98E+02	5.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroethane	75-00-3	6.71E+03	3.90E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloroform	67-66-3	7.95E+03	7.00E-02	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Chloromethane	74-87-3	5.32E+03	1.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromo, 1,2- Chloropropane, 3-	96-12-8	1.23E+03	4.00E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	74-95-3	1.19E+04	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,3-	541-73-1	1.25E+02	1.80E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene, 1,4-	106-46-7	8.13E+01	5.00E-03	7.50E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethene, Trans 1,2-	156-60-5	4.52E+03	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloroethyene, 1,1-	75-35-4	2.42E+03	7.00E-03	7.00E-03	-	ND	ND	-	-	-	-	-	-	-
Dichloroethylene, Cis 1,2-	156-59-2	6.41E+03	7.00E-02	7.00E-02	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,2-	78-87-5	2.80E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Dichloropropane, 1,3-	142-28-9	2.75E+03	4.30E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	100-41-4	1.69E+02	3.00E-02	7.00E-01	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorbutadiene	87-68-3	3.20E+00	8.60E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Ethyl Ketone	78-93-3	2.23E-05	7.10E+00	-	-	-	-	ND	ND	ND	ND	ND	ND	ND

Table 1-6
Quarterly Ground Water Monitoring - Well RHMW2254

Chemical	CAS Number	Solubility[11] 20-25°C mg/L	HDOH[12] EALs mg/L	EPA[13] MCL mg/L	September[1] 2005 mg/L	July[2] 2006 mg/L	December[3] 2006 mg/L	May[4] 2007 mg/L	June[5] 2007 mg/L	September[6] 2007 mg/L	March[7] 2008 mg/L	May[8] 2008 mg/L	October[9] 2008 mg/L	February[10] 2009 mg/L
Methyl Isobutyl Ketone	108-10-1	1.90E+04	1.70E-01	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.00E-03	-	5.00E-04	ND	ND	-	-	-	-	-	-	-
Methylene Chloride	75-09-2	1.30E+04	4.80E-03	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
m-Xylene	108-38-3	1.61E+02	-	-	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	91-20-3	3.10E+01	1.70E-02	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	95-47-6	1.78E+02	-	-	5.00E-04	ND	ND	-	-	-	-	-	-	-
p-Xylene	106-42-3	1.62E+02	-	-	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	100-42-5	3.10E+02	1.00E-02	1.00E-01	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,1,2-	630-20-6	1.07E+03	5.20E-04	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane, 1,1,2,2-	79-34-5	2.83E+03	6.70E-05	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	127-18-4	2.06E+02	5.00E-03	5.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	108-88-3	5.26E+02	4.00E-02	1.00E+00	5.00E-04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	7.00E-02	7.00E-02	-	-	-	ND	ND	2.40E-04	ND	ND	ND	ND
Trichloroethane, 1,1,1-	71-55-6	1.29E+03	2.00E-01	2.00E-01	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethane, 1,1,2-	79-00-5	4.59E+03	5.00E-03	5.00E-03	-	-	-	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	79-01-6	1.28E+03	5.00E-03	5.00E-03	5.00E-04	-	-	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	75-01-4	8.80E+03	2.00E-03	2.00E-03	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead														
Lead	7439-92-1	-	1.50E-02	1.50E-02	-	ND	1.70E-03	ND	ND	ND	ND	ND	ND	-

Legend:
Contaminant exceeds HDOH EALs.
N/A - Not Applicable
"-" = Chemical was not tested.
ND = Chemical not detected.

Source:
1 Chemical Results, September 2005
2 Chemical Results, July 2006
3 Chemical Results, December 2006
4 Chemical Results, May 2007
5 Chemical Results, June 2007
6 Chemical Results, September 2007
7 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, March 2008
8 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, May 2008
9 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, October 2008
10 Quarterly Groundwater Monitoring Report, Red Hill Fuel Storage Facility, February 2009
11 United States National Library of Medicine, National Institute of Health. http://www.nlm.nih.gov/
12 Hawaii Department of Health. Environmental Action Levels. Table D-1b.
13 Environmetal Protection Agency. Contaminant MCLs.

Objectives and Scope of Work

The primary objective of this study was to identify and recommend a viable treatment system to protect the potable water supplied by the Red Hill Water Plant. The system recommendation was based on the previous site investigations and reports on the Red Hill groundwater. This study:

- Developed maximum allowable influent concentration (MAIC) limits for contaminants of concern to ensure compliance with existing regulations, and reduce potential for the treatment facility upset.
- Identified treatment technologies capable of treating contaminants of concern to limits within existing drinking water regulations.
- Identified three viable treatment system alternatives, conducted a hydraulic analysis of each alternative, and provided a budgetary cost estimate and a life cycle analysis for each alternative.
- Recommended the optimum alternative as the basis for establishing a conceptual construction budge and programming project to construct the treatment facility if other environmental studies indicate that such a facility will become necessary.
- Proposed an action level limit for the treatment facility being implemented.

The Scope of work included the tasks below.

- Available documents including previous studies, construction drawings, pump station monitoring data, applicable regulations, and reference material were reviewed.
- Literature searches of water treatment technologies, removal efficiencies, and cost estimations were performed.
- The User Activity was interviewed to discuss and verify the criteria and considerations to be used for identified feasible systems, for the selection of viable systems, and for the selection of a recommended treatment system.
- Maximum allowable loading limits for contaminant of concern were calculated to ensure the treated water compliance with existing regulations, and reduce potential for treatment facility upset.
- Treatment technologies capable of treating contaminants of concern to limits within existing drinking water regulations were evaluated. The conceptual requirements associated with selected treatment technologies, such as space requirements and logistics associated with construction, operation and maintenance, were also investigated.

- Hydraulic analysis of the existing Red Hill Pump Station and transmission pipeline system was conducted to assess the hydraulic limitations of the exiting pump and pipeline system and to facilitate identification of possible modification to existing system that might be needed for incorporation of treatment facility.

- Three viable treatment systems were identified. A preliminary site for each alternative was selected. Site layouts were developed with consideration of the logistics for continued operation and maintenance. A hydraulic analysis of each alternative was performed to ensure that the system can treat and deliver drinking water at the production rates needed.

- Life-cycle economic analyses of the three viable systems were performed. A treatment system was selected as the basis for establishing a conceptual construction budget and programming project to construct the treatment facility.

Organization of Report

The remaining chapters of this report are organized as follows:

Chapter 2	Regulatory Requirements
Chapter 3	Evaluation of Existing Facilities
Chapter 4	Assessment of Drinking Water Treatment Alternatives
Chapter 5	Assessment of Treatment System Alternatives
Chapter 6	Summary and Recommendations

Chapter 2 includes a description of regulations applicable to drinking water standard. Chapter 3 includes a description of existing Red Hill Pump Station. Chapter 4 describes the available treatment technologies for removing organic compounds, and defines the maximum allowable influent concentration and the water treatment facility action level. Chapter 5 includes conceptual evaluations of alternatives treatment system. Chapter 6 summarizes the findings and conclusions of the study and presents the recommended modifications to the water treatment facility.

Chapter 2

Regulatory Requirements

Chapter 2
Regulatory Requirements

General

The federal and state environmental standards applicable to this study were identified. The standards applicable to drinking water quality include the Safe Drinking Water Act, Lead Contaminant Control Act, and the State of Hawaii Safe Drinking Water Standards. The standards regulating VOC emission from air strippers include the Clean Air Act, and State of Hawaii Air Pollution Control regulations. This chapter summarizes the regulatory and guidance documents applicable to the resulting treated water effluent quality and VOC emissions from potential water treatment systems.

Regulations Applicable to Drinking Water

Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act (SDWA, P.L. 93-523), Title XIV of the Public Health Service Act, is the primary federal law for protecting public water supplies from harmful contaminants. The SDWA was first enacted in 1974 and substantively amended in 1986 and 1996. Under the SDWA, the U.S. Environmental Protection Agency (USEPA) established standards for drinking water quality. Originally, the SDWA focused primarily on providing safe drinking water at the tap. The 1996 amendments enhanced the existing law by recognizing source water protection, capacity development, and operator certification. Further, the 1996 amendment made it clear that Federal facilities are subject to fines and penalties for failing to comply with the provisions of the SDWA. A key component of the SDWA is the requirement that USEPA promulgate National Primary Drinking Water Regulations (NPDWRs) or primary standards.

NPDWRs are health-related criteria that require mandatory enforcement. The regulations apply to privately and publicly owned water systems that provide piped water for human consumption to at least fifteen service connections or that regularly serve at least 25 people. The primary standards list seven microorganisms, four disinfection byproducts, three disinfectants, sixteen inorganic chemicals, 53 organic chemicals, and four radionuclides. For each contaminant, EPA established a non-enforceable maximum contaminant level goal (MCLG), an enforceable maximum contaminant level (MCL) and Best Available Technology (BAT) treatment technologies. The MCLs represent an upper limit on the permissible concentrations of regulated contaminants in regulated drinking water supplies. MCLGs are maximum concentrations below which no negative human health effects are known to exist. MCLGs are non-enforceable health goals that may not be achievable or cost effective in some areas, such as small public water systems. The Federal government recognizes BAT treatment techniques as the technologies most likely to reduce contaminants to acceptable levels in drinking water at a reasonable cost. A list of contaminants and their MCLs are included in Appendix A.

In addition to the NPDWRs, EPA established National Secondary Drinking Water Regulations (NSDWRs), or secondary standards, that are intended for control of aesthetic factors. Unlike primary standards, the secondary standards are established as guidelines that are strongly recommended but not required. The secondary standards include fifteen parameters and maximum contaminant levels, which are also included in Appendix A. EPA does not enforce the secondary maximum contaminant levels (SMCLs). Parameters governed by secondary standards have a significant effect on water color, taste, and odor in the drinking water, but are not considered to present a risk to human health at the SMCLs.

The specific requirements of SDWA are contained in Title 40 Code of Federal Regulations (CFR), Parts 141 and 143. Title 40 CFR Part 141 codifies the specific requirement of the SDWA primary standards including MCLs, monitoring and analytical requirements, reporting and record keeping, MCLGs, filtration and disinfection, control of lead and copper, treatment techniques, and information collection requirement for public water systems. Title 40 CFR Part 143 establishes MCLs for contaminants that primarily effect aesthetic qualities and public acceptance of drinking water.

Tile 40 CFR Part 141.80 establishes requirements for corrosion control, source water treatment, lead pipe replacement and public education. The requirements are triggered when lead and copper concentrations exceed the action level. The action level is exceeded if the concentration of lead or copper in more than 10 percent of tap water samples collected during a monitoring period is greater than MCLs.

Lead Contamination Control Act (LCCA)

The Lead Contamination Control Act (LCCA) was passed in 1988 (P.L. 100-572) and further amended the Safe Drinking Water Act. These provisions were intended to reduce exposure to lead in drinking water by requiring the recall of lead-lined water coolers, and requiring EPA to issue guidance documents and testing protocols for States to help schools and day care centers identify and correct lead contamination in school drinking water.

State of Hawaii Safe Drinking Water Standards

The State of Hawaii Department of Health (HDOH) has adopted standards to protect the quality of Hawaii’s drinking water sources from contamination and assure that owners and operators of public water systems provide safe drinking water. These water quality standards are included in the Hawaii Administrative Rules (HAR) Title 11 Chapter 20 Rules Relating to Potable Water Systems. HAR Title 11 contains regulations that govern DOH activities. HAR Title 11 Chapter 20 includes contaminant MCLs applicable to all public water systems that collect, treat and/or sell water, including the Red Hill Water Plant. A copy of the contaminants and their MCLs as regulated by the HDOH Safe Drinking Water Branch is included in Appendix A.

Regulations Applicable to Air Quality

Clean Air Act

The Clean Air Act seeks to protect human health and the environment from emissions that pollute ambient or outdoor air. It requires EPA to establish minimum national standards for air quality, and assigns primary responsibility to the States to assure compliance with the standards.

Section 112 of the Clean Air Act establishes programs for protecting public health and the environment from exposure to toxic air pollutants. Section 112 established a list of hazardous air pollutants (HAPs) including VOCs. The Section requires the Administrator to study hazardous air pollutants emitted by publicly owned treatment works, identify the discharges that contribute to the emissions, and demonstrate control measures for such emissions. It also requires the administrator to "provide for control measures that include pretreatment of discharge causing emission of hazardous air pollutants and process or product substitutions or limitations that may be effective in reducing such emissions" when promulgating any standard under this Section. The proposed Red Hill water treatment facility is classified as a publicly owned treatment works. The VOC emissions from air strippers, if implemented as part of the treatment facility, must therefore comply with the standards established under the Clean Air Act.

The specific requirements of hazardous air pollutants for source categories are contained in Title 40 CFR Part 63. Title 40 CFR Part 63 Subpart VV applies to the control of air emissions for oil-water separator and organic-water separators such as air strippers. Title 40 CFR Part 63 Subpart VVV indicates that there is no control requirement for a new or reconstructed non-industrial publically own treatment works, which is not a major source of HAP. Major source is defined as "any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants, unless the Administrator establishes a lesser quantity, or in the case of radionuclides, different criteria from those specified in this sentence."

State of Hawaii Air Pollution Control

The HDOH has adopted standards for air pollution control. These air pollution control standards are included in HAR Title 11, Section 60.1, Air Pollution Control. HAR Section 11-60.1 includes general requirements and prohibitions, and the regulations for open burning, covered and noncovered sources, and hazardous air pollution emissions.

VOC water separation equipment must be equipped with a properly installed vapor loss control device, in accordance with HAR Section 11-60.1-40 (Appendix A), if the separator "receives effluent water containing two hundred gallons (seven hundred sixty liters) or more of any volatile organic compound a day from any equipment that is processing, refining, treating, storing, or handling volatile organic compounds having a Reid vapor pressure of 0.5 pounds per square inch or greater". The existing USTs contain JP-5 and F-76. Although the proposed treatment facility capacity is 16 mgd and exceeds the 200 gallon per day flow rate limitation indicated in the HAR, Reid vapor pressures (RVPs) of JP-5 and F-76 are almost zero psi at room temperature. No vapor recovery equipment is required for VOC water separation equipment at the treatment facility.

HAR Section 11-60.1 Subchapter 9 defined 188 hazardous air pollutants, which including VOCs. According to HAR §11-60.1-179(d), a new major source of hazardous air pollutant emission can be approved only when both of the following apply:

1) “The total allowable emissions of the hazardous air pollutant from the stationary source are below 0.1 pounds per hour”.

2) The significant ambient air concentration for the hazardous air pollutant as determined in accordance with HAR §11-60.1-179(c) is greater than 200 μg/m^3 for all applicable averaging periods.

Otherwise, the owner or operator of the source shall comply with one or more of the following conditions according to HAR §11-60.1-179(b):

1) Demonstrate that the emissions of hazardous air pollutants from the source will not result in, or contribute to, any significant ambient air concentration as defined in §11-60.1-179 (c).

2) Demonstrate that the applicable significant ambient air concentration in §11-60.1-179 (c) is inappropriate for the hazardous air pollutants in question and that the emission of hazardous air pollutants from the source will not result in, or contribute to, any ambient air concentration which endangers human health.

Based on the 16 mgd design capacity of the proposed treatment facility, the proposed MAIC of each contaminant, and the proposed design air stripping removal rates as indicated in Chapter 4, the hazardous air emission rate from the proposed water treatment facility is approximately 77 lbs/hour as documented in Appendix B. Therefore, future investigation of gas emissions from the proposed air stripper equipment will be required to demonstrate compliance with at least one of the conditions stated under HAR §11-60.1-179(b).

Chapter 3

Evaluation of Existing Facilities

Chapter 3
Evaluation of Existing Facilities

General

The initial portion of this chapter provides background information on the existing Red Hill Water Plant and its related facilities. The latter portion of this chapter describes the hydraulic analysis of the Red Hill pump station conducted to evaluate the existing pumps and pipeline capacity.

Existing Red Hill Water Plant and Relative Facilities

Red Hill Water Plant is located in Pearl Harbor Red Hill Tunnel on the island of Oahu. The water plant is owned, operated, and maintained by the Naval Facilities Engineering Command, Hawaii (NAVFAC Hawaii). The Red Hill Water Plant was constructed in 1942 and consists of an 1174-foot long development tunnel and four deep well vertical turbine pumps. Up to 16 mgd of water can be drawn from the infiltration tunnel, providing approximately 24 percent of potable water supply to the Pearl Harbor Complex water system, which serves approximately 52,200 military consumers. Typically, 3 to 3.5 mgd is withdrawn daily from the Red Hill Water Plant. The water production rate varies throughout the year due to changes in pump sequencing between Red Hill and the Waiawa Pump Station.

The pump station layout and section plans are shown on Figures 3-1 and 3-2. Pumps Nos. 1 and 2 of the water plant were replaced between 2002 and 2004 with 7200 gpm pumps; Pumps Nos. 3 and 4 are each rated at 6500 gpm. According to NAVFAC Hawaii personnel, Pump No. 3 provides the lowest output of the four pumps. Flow data monitored by the venturi meter located in the Harbor tunnel were provided by NAVFAC Hawaii personal for the period from January 1, 2008 to April 1, 2009. The pump flow data analysis indicated that average pumping rate for that period was approximately 6300 gpm, as summarized in Table 3-1. A copy of a sample pump flow data analysis is included in Appendix B. At the time of a site visit in April 2009, only Pump No. 1 was in operation, and the discharge line of Pump No. 2 had been removed for repair. Pump No. 4 had been removed from service. According to the venturi meter reading, the flow rate of Pump No. 1 was 10.45 mgd or approximately 7257 gpm.

According to NAVFAC Hawaii personal, pumps at the Red Hill and Waiawa Water Plants are automatically activated by water level at the two downstream potable water storage tanks, S-1 and S-2. Tanks S-1 and S-2 have overflow spillway elevations of 178.5 feet MSL and overall tank depths of 40 feet. Three pumps are typically utilized in the operating sequence. One pump at Waiawa is designated as the lead pump and operates continuously to maintain the desired distribution system pressure and meet system demands. The lead pump starts when tank water depth drops to 37.0 feet and stops when the water depth rises to 37.5 feet. During the dry summer months, a pump at Waiawa is designated as the second pump in the sequence and a pump at Red Hill is designated as the third pump in the sequence. During the wet winter months, a pump at Red Hill is designated as the second pump in the sequence and a pump at Waiawa is designated as the third pump in the sequence. The designated second pump starts when tank water depth drops to 30.0 feet and stops when water depth rises to 36.0 feet. The designated

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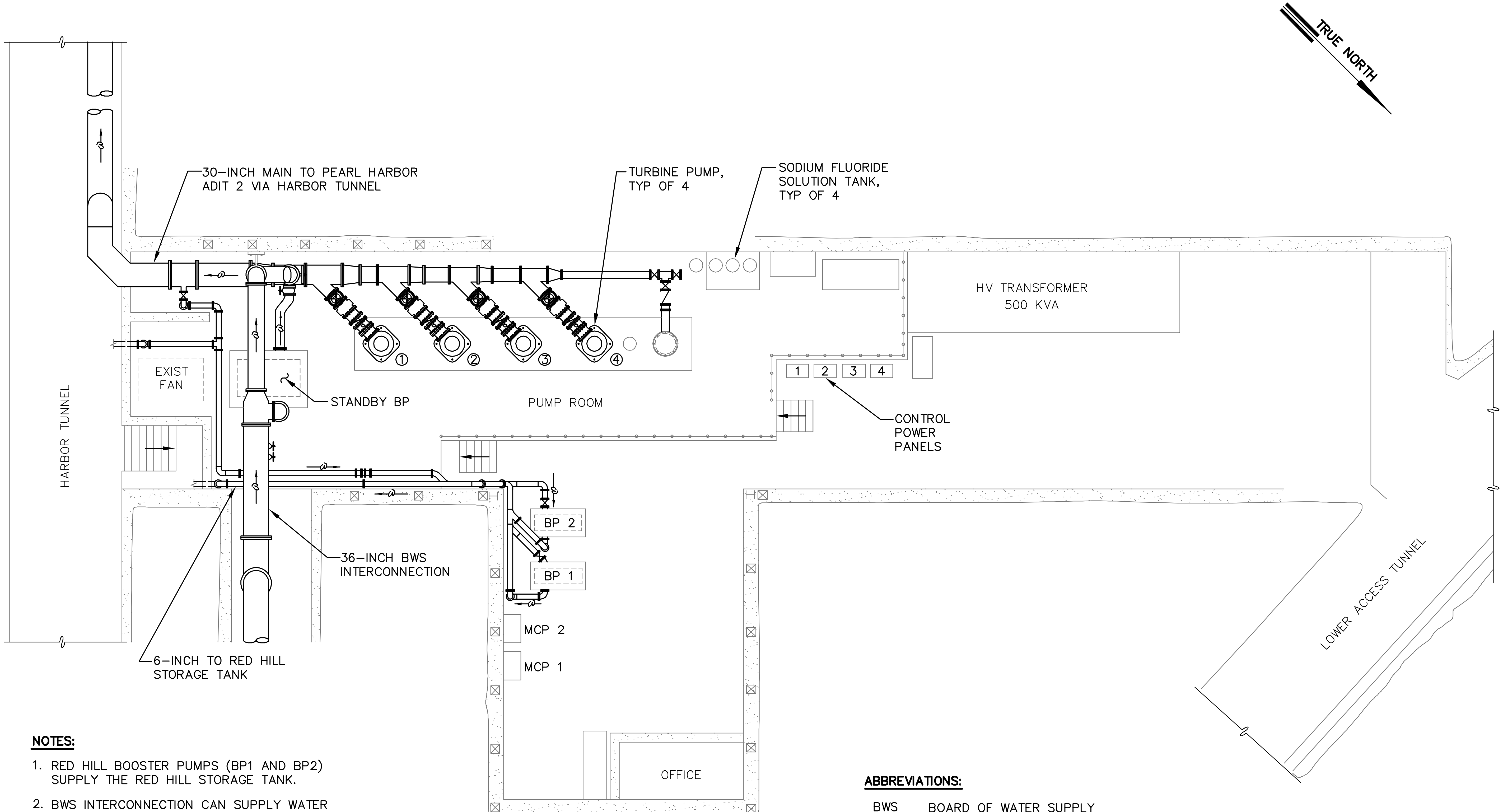

NOTES:

1. RED HILL BOOSTER PUMPS (BP1 AND BP2) SUPPLY THE RED HILL STORAGE TANK.
2. BWS INTERCONNECTION CAN SUPPLY WATER TO NAVY SYSTEM THROUGH STANDBY PUMP (STANDBY BP).

ABBREVIATIONS:

BWS	BOARD OF WATER SUPPLY
BP	BOOSTER PUMP
MCP	MOTOR CONTROL PANEL

WATER PLANT LAYOUT

NOT TO SCALE

DATE: 01/05/09
SCALE: 1 = 1
FILE: 2008014-FIG-08

PM: FTH
OPER: FA,HCI
REVISED: 06/17/09

HDR | HPE Hawaii Pacific Engineers, Inc.

EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII

PEARL HARBOR — OAHU, HAWAII

RED HILL WATER PLANT, BUILDING S-307

FIGURE 3-1

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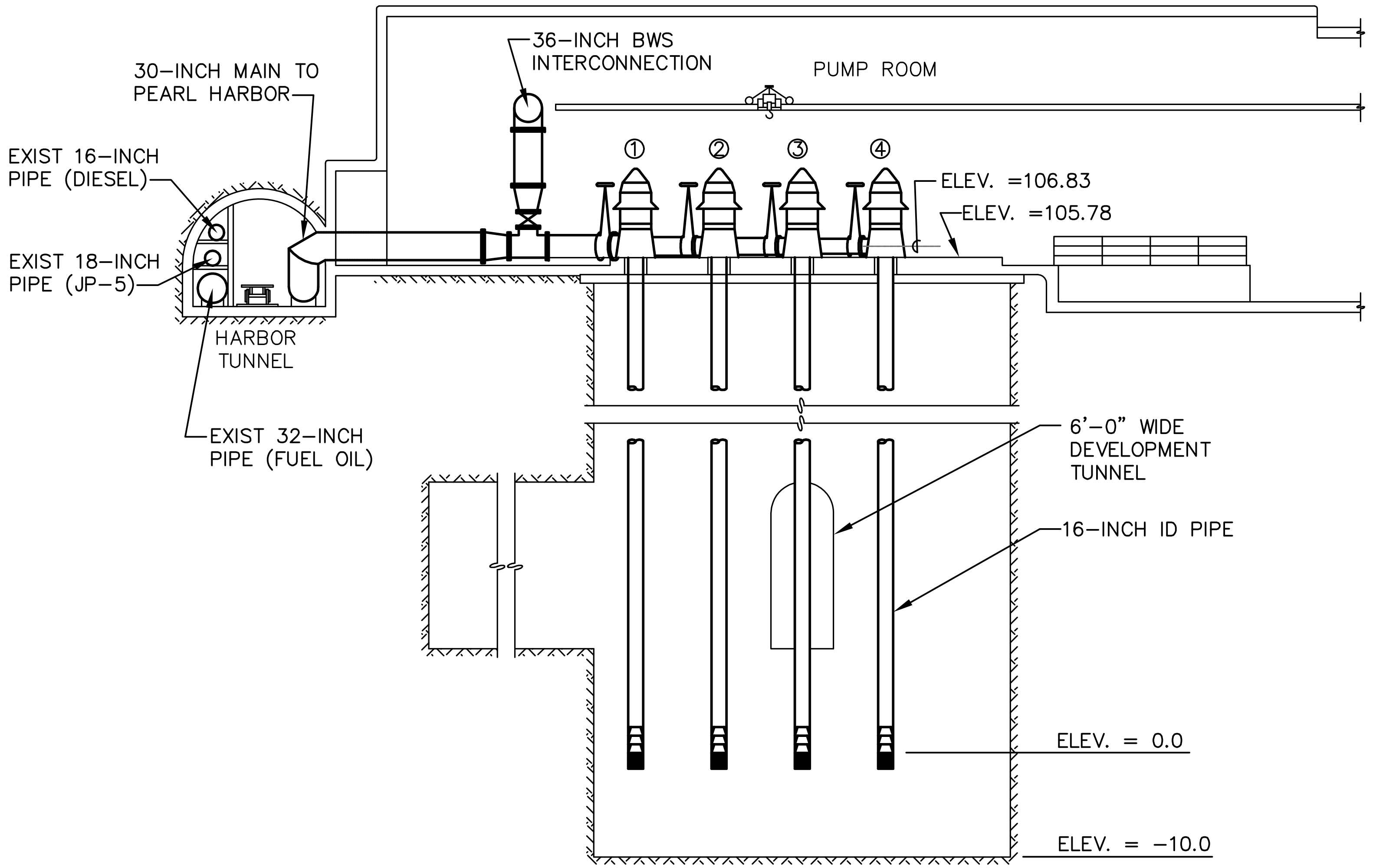
DATE: 01/05/09 PM: FTH
SCALE: 1 = 1 OPER: FAI,HC
FILE: 2008014-FIG-04 REVISED: 06/15/09



SECTION
NOT TO SCALE

HDR / HPE Hawaii Pacific Engineers, Inc.	EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII PEARL HARBOR OAHU, HAWAII	RED HILL WATER PLANT SECTION	FIGURE 3-2

third pump in the sequence starts when water depth drops to 25.0 feet. Because the operating sequence typically utilizes two Waiawa pumps and one Red Hill pump with a Waiawa pump always designated as the lead pump, the majority of the water for the Pearl Harbor complex is supplied by the Waiawa Pump Station.

Table 3-1
Red Hill Water Plant Pump Flow Data Summary

	Average Pump Flow (gpm)	
	2008	**2009**
January	6456	6808
February	6298	6363
March	6654	6049
April	5812	
May	6282	
June	6106	
July	4697	
August	6151	
September	6133	
October	5254	
November	7116	
December	6670	
Average	6136	6407

To prevent cavitation of the pumps, the water level at the Red Hill well facility is maintained at no lower than 8.0 feet MSL. If the well level drops below 8.0 feet, a control valve near Pump No. 4 automatically opens to return pumped water to the well. According to NAVFAC Hawaii personnel, only two pumps can be operated simultaneously. This limitation is imposed to minimize the potential for up-coning of seawater into the fresh water aquifer and to prevent pump cavitation. An interconnection with the City and County of Honolulu Board of Water Supply (BWS) system is available at the Red Hill pump station and is located upstream of the venturi meter. A booster pump system is available to increase pressure if needed to feed BWS water into the Red Hill pump discharge pipeline. However, the booster pump is not normally operated because pressure in the BWS system is typically higher than the pressure in the well pump discharge pipeline. In addition to providing water to the Pearl Harbor Complex water system, a 6-inch pipe connected to two Gould booster pumps within the water plant provides fresh water to the storage tank at the Red Hill Fuel Storage Facility site and the FISC fuel tunnel complex.

Fresh water drawn from the infiltration tunnel of Red Hill Water Plant is injected with chlorine and sodium fluoride solution before discharge into the transmission main connected to the Halawa Reservoir, tanks S-1 and S-2. The transmission main between the water plant and Tanks S-1 and S-2 was replaced in 2001 with a 30-inch ductile iron, class 250 pipeline.

Hydraulic Analysis of Existing Pumps and Pipelines

A computer program was used to analyze the existing pumping capacity at the Red Hill Water Plant. The computer analysis program used for this study was KYPIPE. KYPIPE was developed by the University of Kentucky to calculate steady state flows and pressures for pipe distribution systems. The program uses data inputs for a water distribution system, such as pipe lengths, sizes, Hazen-Williams roughness coefficient C-value, pump curves or motor power, minor losses, elevations, demands, reservoir elevations and dimensions, and pressure regulating valve (PRV) set points. KYPIPE accommodates elements such as closed lines, check valves, PRVs, minor losses, pipe roughness and pumps. The program computes flows, velocities, losses in each pipe segment, and the flow in and out of the reservoir, including the water depth in reservoirs.

The KYPIPE analysis of the existing pumps was used to determine the existing pump capacities, and to calibrate with the pump flow data corresponding to Friday 03 April 2009 at 10.45 mgd (7252.3 gpm). The KYPIPE model for the existing Red Hill Water Plant distribution system consists of 22 pipes, 14 primary nodes, one storage tank, four pumps and one supply reservoir. A schematic for the KYPIPE model with pipe and junction node numbers is indicated in Appendix D.

The KYPIPE model incorporated the following assumptions:

- The infiltration channel of the Red Hill Water Plant is similar to a supply reservoir with water levels as low as (-)10 feet MSL, and a constant grade water level of 8 feet MSL.

- The Utility System Assessment for the Pearl Harbor Complex Water System (USA) (Engineering Concepts, 2006), indicated a C-factor of 130 for the transmission main and also indicated that the C-factor remains the same for 10 years. The C-factor of the transmission main is 130.

- Tanks S-1 and S-2 are interconnected and act as a single reservoir located at 140 feet MSL, with a maximum level of 178.5 feet MSL, and minimum level of 165 feet MSL.

- Due to the unavailability of pump curves for the four existing pumps, the analysis was based on assuming constant power of 400 HP at 77 percent efficiency. A pump efficiency calculation is included in Appendix B.

Pipe characteristics, minor loss coefficients of fittings, and other system parameters were adjusted to match the outgoing flow observed during the April 2009 site visit. The KYPIPE output file for the calibration run is included in Appendix C. The model analysis result indicated that with Pump 1 running alone, the water plant provided approximately 7644 gpm, or an equivalent flow rate of 11 mgd. This is slightly higher than the 10.45 mgd observed, but was considered to be an acceptable level of accuracy for this study.

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Chapter 4

Assessment of Drinking Water Treatment Alternatives

Chapter 4
Assessment of Drinking Water Treatment Alternatives

General

This chapter identifies and evaluates drinking water treatment alternatives for removing PAH, VOCs and TPH, which have been identified in the groundwater below the Red Hill fuel storage facility. The USEPA has evaluated many types of organic compounds for safe drinking water purposes and established MCLs for the identified organic compounds. The best available technologies (BATs) for removing organic compounds as indicated by USEPA are GAC, air stripping, and oxidation. Volatile organic compounds are typically removed from water by aeration. For compounds that are non-volatile or semi-volatile, adsorption by GAC is the preferred treatment technology. Therefore, air stripping and GAC are typically used in combination when both volatile and non-volatile organic compounds are present. This chapter introduces and evaluates the above BATs, and recommends an optimum treatment system for the Red Hill Water Plant.

The methods adopted for defining the maximum allowable influent concentration and the treatment facility action level is also described in this chapter. The maximum allowable influent concentration is the estimated maximum concentration of a contaminant that can be received at the treatment facility while ensuring that the treated water meets federal and State regulations. The facility action level is an estimated contaminant concentration at which the proposed water treatment technology at the Red Hill facility must be implemented. The development of the proposed facility action level is intended to allow sufficient time for requesting funding and completing design and construction before water quality at Red Hill Water Plant exceeds federal and State MCLs for the identified organic compounds.

Best Available Technologies (BATs)

The Safe Drinking Water Act (SDWA) though 1986 Amendments requires the establishment of new maximum contaminant level (MCLs) for many organic contaminants. As a result, regulations passed in 1987 designated best available technologies (BATs) ands MCLs for organic contaminants. USEPA identified 21 contaminant MCLs that apply to community and non-transient, non-community water systems (40 CFR §141.61 (a) and (c)). USEPA also requires water utilities with these contaminants to provide removals at least equivalent to those achieved by the designated BATs. Granular activated carbon (GAC) is the BAT for the majority of organic contaminants (EPA §141.61 (b)). Air stripping is a cost-effective method for reducing VOCs (UFC 3-230-08a). Oxidation is a BAT for groundwater containing glyphosate, which was not observed in Red Hill site. Combining air stripping and GAC into a two-step treatment train has been suggested as the most effective method for achieving low effluent levels of VOCs. In a municipal-scale treatment plant combining these processes, air stripping is used as a first step for the bulk reduction of VOCs in the water, and activated carbon is used as a second step to further reduce the residual VOC concentrations (McKinnon and Dyksen, 1984; Stenzel and Gupta, 1985; U.S. EPA, 1991a). In addition, the use of air stripping prior to GAC can significantly extend carbon bed life. Thus combining air stripping and GAC is recommended for the proposed water treatment facility.

Air Stripping

Air Stripping involves the mass transfer of organic contaminants from water to air by increasing the contaminated water surface area exposed to air. Air strippers typically include packed towers (also called packed columns), diffused aeration, tray aeration (also called low-profile tray stripper) and spray aeration. For groundwater treatment, this process is typically conducted in packed columns or low-profile tray strippers. The packed tower is the most commonly used air stripper due to its lower cost, higher design capacity, and lower air requirement. Low profile tray strippers are easier to clean and are more compact.

Air strippers are typically used for the removal of volatile, dissolved contaminants having low solubility and high Henry's Law constant. Generally, organic compounds with a Henry's Law constant greater than 0.01 atm-m^3/mol are considered to be amenable to air stripping (FRTR). For compounds with low volatility, i.e., lower Henry's Law constant, at ambient temperature, preheating of the groundwater may be required to achieve a high removal rate. However, studies indicated that heating of influent water to increase removal effectiveness is generally not cost-effective. Typically, compounds such as TCE, DCE, PCE, chloroethane, and BTEX are efficiently removed by air stripping. However, contaminants, such as PAH, with low volatility, or contaminants with high water solubility, such as acetone, MEK, and MTBE, are not efficiently removed by air stripping. Air strippers are capable of removing more than 99 percent of most VOC contaminants. Generally, increasing the depth of the packing or the number of trays, or the airflow volume can also increase the removal rate. The volatilized contaminants are either released directly to the atmosphere or are treated and then released.

The operation and maintenance of an air stripping system can require a significant financial commitment over a long term. Potential inorganic or biological fouling exists when calcium concentration exceeds 40 mg/l, iron concentration exceeds 0.3 mg/l, or magnesium concentration exceeds 0.05 mg/L. Pretreatment or periodic column cleaning is typically required. When fouling is expected, low profile air strippers are often desirable, due to its ease of cleaning. Because the potential for inorganic or biological fouling was considered to be low, packed column air strippers were selected for the proposed water treatment facility.

In air strippers for groundwater treatment, the water is generally pumped directly to the top of the packed column. Treated water is collected at the bottom of the column in a clear well, from which water is usually pumped directly to the distribution system or downstream treatment processes. Packing materials are designed to provide low pressure drop for air passing through the column with maximum air-water contact area. Air is generally introduced at the base of the column by blowers driven by electric motors. Screens are typically provided at the air inlet to prevent insects and airborne contaminants from being blown into the column.

The rate at which a volatile compound is removed from water depends on the air-to-water ratio, height of packing in the column, available surface area for mass transfer, water loading rate, air temperature, and water temperature. In general, higher air-to-water ratio, increased packing height, and higher water temperature result in higher VOC removal. However, it has been found that heating the influent water to increase removal efficiency is not generally cost-effective. Typical design criteria for packed column stripper are presented in Table 4-1.

Table 4-1
Typical Packed Tower Air Stripper Design Parameters*

Parameters	Range of Values
Air-to-Water Ratio	Typically 30:1 to 40:1, but may range up to 100:1
Tower diameter	3 to 10 ft
Tower Height	15 to 30 ft
Packing depth	10 to 20 ft
Hydraulic Loading Rate	25-30 gpm/ft^2
Water Temperature	45°F-75°F (typical groundwater temperature)
Gas Pressure Drop	0.25 to 0.5 inch water column per foot of packing depth

*Source: AWWA/ASCE, 1997; HDR Engineering, 2001.

The emission of contaminated exhaust air from the air strippers creates potential air quality considerations. The transfer of VOCs from water to air might be a concern depending on site conditions, local regulations, type of VOCs, daily quantity of water to be processed, the contaminant level, local air quality, and local meteorological conditions. The emission rate must be evaluated in the context of applicable air quality regulations and other site-specific factors. If the emission rate is unacceptable, off-gas treatment, such as gas-phase GAC treatment, is required before releasing the stripped gas to the atmosphere. According to HAR Title 11 Chapter 60, a vapor recovery system is not required for the proposed Red Hill water treatment facility. However, further treatment of the discharge air from the air stripper equipment might be needed to meet the conditions stipulated in HAR §11-60.1-179(b).

For the proposed water treatment facility, it is estimated that the following facilities would be needed for the air stripper system:

- Packed tower air strippers.
- Air blowers.
- One underground treated water storage tank.
- Pumps to provide sufficient hydraulic head for downstream treatment.

Branch Environmental Corp, Delta Cooling Towers, and Siemens responded with rough analysis for their equipment. Branch Environmental suggested using eight packed column strippers operating in parallel. Each air stripper column would be 12-feet in diameter by 42 feet tall. Delta Cooling Towers and Siemens responses indicated a smaller footprint. Delta Cooling Towers proposed a four column system. Each air stripper column would be 11-feet in diameter by 5 feet tall. Siemens suggested using a five column system. Each air stripper column would be 12-feet in diameter by 19 feet tall. The configuration with the largest layout requirement was utilized for report. Two additional air stripper columns were added to the desired treatment system configuration to provide redundancy for regular preventive maintenance. The air stripper columns would be operated in a rotational sequence with one air stripper out of service for maintenance. Upon completion of the sequence, all of the air stripper columns will have undergone preventive maintenance.

Granular Activated Carbon Treatment

Granular activated carbon (GAC) treatment is a physicochemical process that removes a wide variety of contaminants by adsorbing them from liquid or gas streams. This treatment is most commonly used to separate organic contaminant from water or air. The two most common reactor configurations for carbon adsorption systems are the downflow fixed bed and upflow expanded bed. GAC applications in drinking water treatment generally utilize the downflow fixed bed configuration in parallel operation (AWWA, 1989). Under parallel operation, the flow is divided equally to each contactor, which significantly reduces the size of each contactor. Series operation is another potential variation. Under series operation, more optimum use of the GAC may be achieved, and premature breakthrough of organic contaminants may be reduced.

GAC liquid phase application is effective for removing contaminants at concentrations less than 10 mg/L from water at nearly any flow rate (FRTR). A large number of studies have demonstrated the ability of GAC to remove a variety of compounds to non-detectable levels (Noonan and Curtis, 1990). Explosives or metals contaminates are typically removed prior to application of water to the GAC bed, due to the potential for those contaminants to clog the carbon pores and reduce GAC bed life. In addition, GAC used for explosive- or metal-contaminants can not be regenerated. Lead is the only metal-contaminate that has been detected in the Red Hill monitoring wells, but the detected concentration is much lower than the HDOH EAL. Therefore, the presence of lead at the low levels detected was not considered to be a significant factor for the proposed treatment facility configuration.

The major design parameters for liquid phase application of GAC are empty bed contact time (EBCT), hydraulic loading rate, GAC usage rate, GAC bed depth, and backwash frequency and rate. Longer EBCT can delay contaminant breakthrough, improve carbon usage rate. Backwash is typically required to remove deposited particles within the GAC beds, and sufficient freeboard should be provided to reduce GAC media losses during backwash. Typical design criteria for a GAC system are presented in Table 4-2. However, the design of a GAC system is not as straightforward as the design of an air stripper. Rather than the basic equations used to determine the size and operating parameters of a stripping tower, GAC design generally requires pilot testing and judgment.

Table 4-2
Typical Granular Activated Carbon Design Parameters*

Parameters	Range of Values
Empty Bed Contact Time (EBCT)	5~25 minutes
Hydraulic Loading Rate	2-10 gpm/ft^2
GAC Depth	10-20 feet
Backwash Frequency	10-20 min several times per day
Backwash Rate	15-20 gpm/ft^2

*Source: AWWA/ASCE, 1997 and AWWA, 1989.

There are two types of GAC systems considered for this study: pre-engineered GAC contactors and built-in-place concrete GAC contactors. Pre-engineered GAC contactors are typically pressure driven, while built-in-place concrete GAC contactors are generally gravity operated. Treated water from GAC contactors is typically stored in a clear well before pumping to downstream treatment facilities or finished water storage tanks.

The typical pre-engineered GAC system recommended for the Red Hill water treatment facility consists of:

- GAC contactors in parallel mode;
- Clear well and pumps to deliver treated water to a finished water storage tank.

Calgon Carbon responded with preliminary recommendations for their equipment. Based on the design capacity of 16 mgd, Calgon Carbon recommended 20 Model 10 pre-engineered treatment units each consisting of two 10-foot-diameter contactors. The calculations for sizing the pre-engineered GAC contactors are included in Appendix B.

The recommended built-in-place concrete GAC system was configured to allow both parallel and series operation. The built-in-place GAC system consists of

- Three primary GAC contactors;
- A clear well and pumps to provide adequate hydraulic head to the downstream secondary contactors ;
- Three secondary GAC contactors;
- A clear well and pumps to deliver treated water to a finished water storage tank.

The calculations for sizing the built-in-place GAC contactors are included in Appendix B. Each proposed primary and secondary GAC contactor is 24-feet wide, 48-feet long, and 25-feet deep. Each contactor is an open-top, rectangular, gravity, downflow, reinforced concrete structure with reinforced concrete troughs for distribution of influent water and collection of spent backwash water.

Studies indicated that small capacity pre-engineered contactors are the most cost effective for smaller treatment plants. Concrete contactors are the most economical at larger plants (AWWA, 1989). Generally, fewer, larger contactors are normally less costly than a larger number of small factory-built contactors, and fewer contactors require less maintenance effort. Because of the size of the proposed treatment facility, built-in-place concrete GAC contactors were considered to be the more cost effective configuration for this study.

Spent carbon from the treatment of streams containing hazardous substances is generally considered hazardous, and its transportation and handling require a site safety plan for personnel protection and establishment of special handling measures. For the proposed treatment facility on-site regeneration of used GAC is not recommended. Typically, separate storage is required for used and virgin GAC. For this study, one virgin GAC storage unit is recommended. The storage unit was sized to provide sufficient space for the GAC for at least two contactors. Each storage unit was sized to be 30-feet wide by 30-feet long and 28 feet tall as indicated in Appendix B.

Combined Air Stripping and Carbon Adsorption

The combined air stripper and GAC treatment system is recommended for the proposed Red Hill treatment facility because of the following factors:

- Air stripping is the BAT for VOCs
- GAC is the BAT for PAHs.
- A combination of air strippers with GAC is the BAT for MTBE.
- According to the Red Hill Quarterly Groundwater Monitoring Reports, the contaminants in the groundwater include PAHs, TPH, VOCs and lead.
- The concentrations of lead reported in the Red Hill Quarterly Groundwater Monitoring Reports were well below the HDOH EAL.

The general process schematic for the proposed water treatment facility is shown on Figure 4-1. The treatment facility will include three main components: air stripping, GAC absorption, and chlorine disinfection. Groundwater from the Red Hill Pump Station would be pumped to the top of the air stripper columns, and treated water from the air strippers would be stored in an underground clearwell. Water from the clearwell would be pumped through the primary and secondary GAC contactors, and the treated water from the GAC system would be stored in an aboveground finished water storage tank after disinfection. The finished water storage tank would also provide backwash water for the primary and secondary GAC contactors.

Maximum Allowable Influent Concentration

The maximum allowable influent concentration (MAIC) is the estimated maximum concentration of a contaminant that can be received at the proposed water treatment facility, and is expressed in the units of milligrams per liter (mg/l or ppm). The MAIC is the estimated highest allowable influent concentration of a contaminant entering the treatment facility. It is defined to ensure that the treated water meets existing federal and State drinking water regulations, and to achieve an estimated carbon bed life of six months. The definition of MAIC was based on the general removal efficiencies of air strippers and GAC treatment, and the chemical and physical properties of each identified contaminant of concern. MAIC is proposed for contaminates detected in the quarterly groundwater reports.

Based on the combined treatment stream of air stripping and GAC, the MAIC was reverse calculated by assuming that the effluent concentration of each contaminant meets the HDOH EAL for groundwater (HDOH, 2008). The HDOH EAL was selected as the desired effluent concentration instead of HDOH MCL, due to the following factors:

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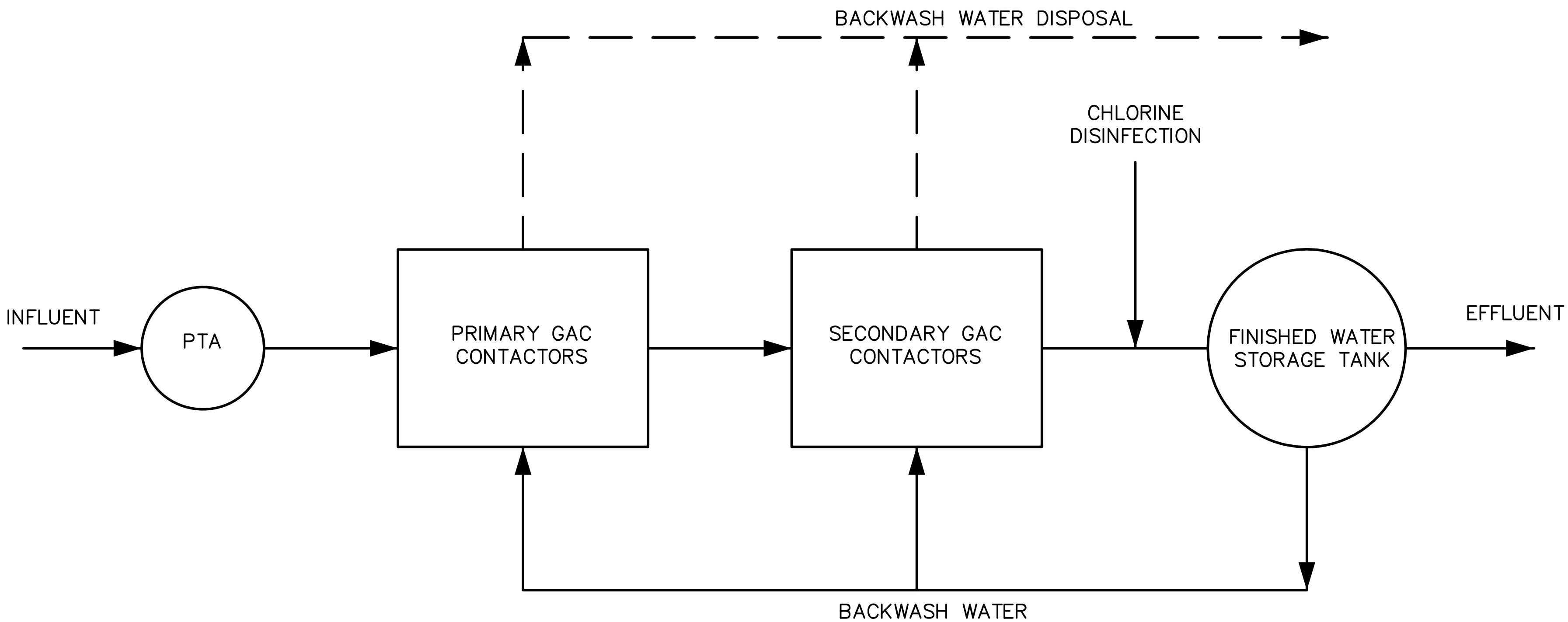

ABBREVIATIONS:

PTA: PACKED TOWER AERATION

GAC: GRANULAR ACTIVATED CARBON

LEGEND:

CLEAN WATER STREAM

WASTE WATER STREAM

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EVALUATE TREATMENT FOR RED HILL WELL,
PEARL HARBOR, HAWAII

PEARL HARBOR OAHU, HAWAII

WATER TREATMENT PROCESS
SCHEMATIC DIAGRAM

FIGURE
4–1

- Contaminant EALs are generally lower than their MCLs.
- EAL is a risk-based criterion. Exceeding the EAL does not necessarily indicate that the constituent concentration poses a hazard. However, it does indicate that additional action is required.
- Establishment of an MCL considers both health and non-health related factors such as the feasibility and cost of treatment. It is the maximum permissible level of a contaminant in the drinking water delivered to a user of a public water system. The contaminant MCL should not be exceeded.

A copy of the HDOH EALs is included in Appendix A. The final groundwater action level is conservatively adopted as the target effluent concentration for the treated water.

Although the removal efficiency of air stripping depends on the air-to-water ratio, mass transfer contact area, height of packing tower, and air/water temperature, studies indicated that air stripping removal efficiencies for the majority of organic compounds ranges from 70 percent to 100 percent (Wang et al, 2006). Chlorinated solvents, such as TCE, PCE, and BTEX compounds can be efficiently removed by air stripping, and the removal efficiencies of these contaminants typically ranges from 99 percent to 99.9 percent. From a conservative standpoint, air stripping removal rates for BTEX and TCE were set at 99 percent. MTBE removal efficiency was set at 90 percent due to its low volatility and high water solubility. Air stripping removal rates for VOCs other than TCE, BTEX and MTBE were conservatively set at 90 percent. Contaminants with Henry's law constants less than 10^{-5} atm-m^3/mol volatilize slowly from water, and their removal in an air stripper is relatively slow and incomplete (Vesilind and DiStefano, 2005). Accordingly, air stripping removal rates for contaminants other than VOCs with Henry's Law constant less than10^{-5} atm-m^3/mol were conservatively set at zero percent. Removal rates for the remaining contaminants were set at 80 percent.

Studies indicated that GAC removal efficiency typically ranges from 70 percent to 100 percent (Wang et al, 2006; Hendricks, 2006). GAC adsorption capabilities for MTBE and BTEX are low, and these contaminants will typically be the first to break through (Noonan and Curtis, 1990; Kavanaugh et al, 2004). The effectiveness of GAC for removal of MTBE has been limited by its poor physical and chemical adsorption characteristics. These MTBE characteristics result in large, costly GAC beds, along with more frequent GAC replacement. In addition, carbon usage rate is significantly increased when MTBE influent concentration is high, or MTBE is present with other organic matter (Kittrell, 2002; Kavanaugh et al, 2002). Consequently, GAC removal efficiency was conservatively set to 80 percent for the majority of contaminants. The GAC removal efficiency for MTBE was conservatively set at zero percent. Due to the high removal efficiency of BTEX and TCE by air stripping and its low removal efficiency by GAC, the target air stripper effluent concentration of BTEX was set at the HDOH EALs.

A summary of the contaminants and corresponding concentrations detected in the quarterly groundwater reports is presented in Table 4-3. The table includes the contaminants CAS numbers, solubility, Henry's Law constant, HDOH EAL, and EPA MCL. The reverse calculation for the estimated MAIC of each contaminant is also shown in Table 4-3.

Table 4-3
Estimated Maximum Allowable Influent Concentrations (MAICs)

Chemical	CAS Number	Solubility[1] 20-25°C mg/L	Henry's Constant[1] atm.m^3/mole	HDOH[2] EALs mg/L	EPA[3] MCL mg/L	GAC[4] Removal 80.0%	GAC[5] Infl. Conc. mg/L	PTA[6] Removal 90.0%	PTA[5] Infl. Conc. mg/L
Petroleum									
* TPH (middle distillates)	-	-	-	1.00E-01	-	80.0%	5.00E-01	0.0%	5.00E-01
TPH (gasolines)	-	-	-	1.00E-01	-	80.0%	5.00E-01	0.0%	5.00E-01
PAH (Semi-Volatile)									
Acenaphthene	83-32-9	3.90E+00	1.84E-04	2.00E-02	-	80.0%	1.00E-01	80.0%	5.00E-01
Acenaphthylene	208-96-8	1.61E+01	1.40E-04	2.40E-01	-	80.0%	1.20E+00	80.0%	6.00E+00
Anthracene	120-12-7	4.34E-02	5.56E-05	7.30E-04	-	80.0%	3.65E-03	0.0%	3.65E-03
Benzo(a)Anthracene	56-55-3	9.40E-03	1.20E-05	2.70E-05	-	80.0%	1.35E-04	0.0%	1.35E-04
Benzo(a)Pyrene	50-32-8	1.62E-03	4.57E-07	1.40E-05	2.00E-04	80.0%	7.00E-05	0.0%	7.00E-05
Benzo(b)Fluoranthene	205-99-2	1.50E-03	6.57E-07	9.20E-05	-	80.0%	4.60E-04	0.0%	4.60E-04
Benzo(g,h,i)Perylene	191-24-2	2.60E-04	3.31E-07	1.00E-04	-	80.0%	5.00E-04	0.0%	5.00E-04
Benzo(k)Fluoranthene	207-08-9	8.00E-04	5.84E-07	4.00E-04	-	80.0%	2.00E-03	0.0%	2.00E-03
Chrysene	218-01-9	2.00E-03	5.23E-06	3.50E-04	-	80.0%	1.75E-03	0.0%	1.75E-03
Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	1.23E-07	9.20E-06	-	80.0%	4.60E-05	0.0%	4.60E-05
Fluoranthene	206-44-0	2.60E-01	8.86E-06	4.00E-02	-	80.0%	2.00E-01	0.0%	2.00E-01
Fluorene	86-73-7	1.69E+00	9.62E-05	2.40E-01	-	80.0%	1.20E+00	0.0%	1.20E+00
Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	3.48E-07	9.20E-05	-	80.0%	4.60E-04	0.0%	4.60E-04
* Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	5.80E-04	-	-	-	-	-	-
* Methylnaphthalene, 1-	90-12-0	2.58E+01	5.14E-04	4.70E-03	-	80.0%	2.35E-02	80.0%	1.18E-01
* Methylnaphthalene, 2-	91-57-6	2.46E+01	5.18E-04	1.00E-02	-	80.0%	5.00E-02	80.0%	2.50E-01
* Naphthalene	91-20-3	3.10E+01	4.40E-04	1.70E-02	-	80.0%	8.50E-02	80.0%	4.25E-01
Phenanthrene	85-01-8	1.15E+00	4.23E-05	7.70E-03	-	80.0%	3.85E-02	0.0%	3.85E-02
Pyrene	129-00-0	1.35E-01	1.19E-05	2.00E-03	-	80.0%	1.00E-02	0.0%	1.00E-02
VOC									
Benzene	71-43-2	1.79E+03	5.55E-03	5.00E-03	5.00E-03	0.0%	5.00E-03	99.0%	5.00E-01
Bromomethane	74-83-9	1.52E+04	7.34E-03	8.70E-03	-	80.0%	4.35E-02	90.0%	4.35E-01
Ethylbenzene	100-41-4	1.69E+02	7.88E-03	3.00E-02	7.00E-01	0.0%	3.00E-02	99.0%	3.00E+00
Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.87E-04	5.00E-03	-	0.0%	5.00E-03	90.0%	5.00E-02
m-Xylene	108-38-3	1.61E+02	7.18E-03	-	-	80.0%	-	90.0%	-
* Naphthalene	91-20-3	3.10E+01	4.40E-04	1.70E-02	-	80.0%	8.50E-02	90.0%	8.50E-01
o-Xylene	95-47-6	1.78E+02	5.18E-03	-	-	80.0%	-	90.0%	-
p-Cymene	99-87-6	2.34E+01	1.10E-02	-	-	80.0%	-	90.0%	-
Toluene	108-88-3	5.26E+02	6.64E-03	4.00E-02	1.00E+00	0.0%	4.00E-02	99.0%	4.00E+00
Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	1.42E-03	7.00E-02	7.00E-02	80.0%	3.50E-01	90.0%	3.50E+00
Trichloroethylene	79-01-6	1.28E+03	9.85E-03	5.00E-03	5.00E-03	0.0%	5.00E-03	99.0%	5.00E-01
Xylenes	1330-20-7	1.06E+02	6.63E-03	2.00E-02	1.00E+01	0.0%	2.00E-02	99.0%	2.00E+00

Notes:
* Contaminant exceeds HDOH EALs. Quarterly Groundwater Monitoring Report.
1 United States National Library of Medicine, National Institute of Health. http://www.nlm.nih.gov/
2 Hawaii Department of Health. Environmental Action Levels. Table D-1b.
3 Environmetal Protection Agency. Contaminant MCLs.
4 L Wang, Y Hung and N Shammas, Advanced Physicochemical Treatment Process, p.9, 2007. GAC removal rate 70-100%
5 Influent Concentration = HDOH EAL / (100% - Air Stripper Removal %)
6 Kawamura, Susumu. Integrated Design and Operation of Water Treatment Facilities, p.550. 2000. Removal rates range from 90% to 99.995%.
7 "-" data not available.

The estimated GAC bed life can be estimated based on the Freundlich isotherm equation. The Freundlich isotherm equation is an empirical equation, which gives a reasonably accurate description of the adsorption of organic compounds in water. Based on the treatment facility design capacity of 16 mgd and the MAIC, the estimated GAC bed life of the proposed facility is approximately nine months. The calculation is included in Appendix B. It should be noted that the isotherm constants vary with the type of activated carbon and the type of water. Therefore, the estimated GAC bed life should be considered to be only a rough approximation. Pilot testing and adjustment is generally required to determine the expected GAC bed life for actual design.

Treatment Facility Action Level

The treatment facility action level is an estimated contaminant concentration that, when observed, would initiate implementation of the proposed treatment facility. Because implementation would require programming and funding of the project in addition to design and construction, the facility action level should allow sufficient time for the full implementation process to be completed.

Limited modeling was completed for the Red Hill Bulk Fuel Storage Facility Final Technical Report (TEC 2007) and established TPH and benzene as the primary potential contaminants of concern. The modeling indicated that the TPH EAL at the Red Hill Well would be exceeded only if an LNAPL plume covering an area of at least 407,000 square feet existed and were located within 695 feet of the end of the Red Hill Well infiltration tunnel. The existence of an LNAPL plume would be necessary to continue to allow TPH and benzene to dissolve into the ground water to offset the reduction of these constituents occurring because of biological consumption, diffusion, adsorption, and other mechanisms. Under these conditions, the LNAPL plume would probably encompass the area where RHMW01 is located. Modeling results for benzene similarly indicated that the benzene EAL would be exceeded only if an LNAPL plume existed within proximity to the Red Hill Well infiltration tunnel. Under these conditions, the LNAPL plume would similarly encompass the area where RHMW01 is located. Site specific risk-based levels for TPH and benzene were established as a result of the modeling and were set at the effective solubility limits for TPH and benzene at RHMW01, RHMW02, and RHMW03 based on the assumption that JP-5 or heavier fuels would continue to be stored at the fuel storage facility.

Additional data and more extensive investigations would be needed to enable simulation of the movement of a plume from a source to a location where the Red Hill Well would be impacted. However, the results of the limited modeling and available ground water monitoring results provides a basis for establishing action levels for initiating construction of a treatment facility. The limited modeling conducted for the Red Hill Bulk Fuel Storage Facility Final Technical Report (TEC 2007) established that an LNAPL plume would need to exist within 695 feet of the Red Hill Well infiltration tunnel for TPH or benzene EALs to be exceeded at the Red Hill Well. The modeling also established that the LNAPL plume would probably encompass the area at RHMW01. Results from monitoring conducted from September 2005 through February 2009 indicate TPH concentrations at RHMW02 ranged from 2310 µg/L to 4540 µg/L and TPH concentrations at RHMW01 ranged from 261 µg/L to 574 µg/L. The TPH concentrations at RHMW01 are approximately an order of magnitude lower that the TPH concentrations at

RHMW02, which suggests that significant reductions are occurring over time and distance as indicated by the modeling. TPH concentration at RHMW02 trended upwards significantly from March 2008 through February 2009. The upward trend at RHMW02 did not appear to have been reflected in the TPH concentrations at RHMW01, which suggests that a significant time period elapses before conditions at RHMW02 are reflected at RHMW01.

At this time, based on the available information and data, the treatment facility action levels below are suggested. If either action level is exceeded, the process for programming and constructing the treatment facility should be initiated. The action levels should continue to be evaluated and revised if additional data becomes available.

RHMW01	TPH greater than or equal to 2000 µg/L
RHMW02	TPH greater than or equal to 4500 µg/L for an extended time or if a light non-aqueous phase liquid plume is observed

It is also recommended that at least one additional monitoring well be constructed down-gradient from the Red Hill Bulk Fuel Storage facility, between RHMW01 and the Red Hill Well infiltration tunnel. The purpose of the well would be to provide data to better assess whether the potential contaminants are migrating towards the Red Hill Well, whether attenuation of contaminant concentrations is occurring, and the net rate of contaminant migration towards the Red Hill Well.

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Chapter 5

Assessment of Treatment System Alternatives

Chapter 5
Assessment of Treatment System Alternatives

General

This chapter identifies and evaluates three alternative systems to established conceptual space requirements, select a preliminary site, and develop a site layout. Alternatives were only developed to the level of detail required to determine the relative merits of each alternative. Hydraulic analysis for each alternative is also conducted to ensure that the system can treat and deliver drinking water at the production rates. Each alternative was evaluated based on a set of criteria established combining monetary criteria, life cycle costs, and non-monetary criteria. The evaluation of alternative systems is presented at the end of this chapter.

Basis for Comparative Evaluation

Alternatives were evaluated based on criteria established in this study. The criteria were selected to enable a comprehensive analysis of each alternative system. Alternative system were identified then evaluated with respect to:

- Impact to Red Hill Water Plant
- Cost-Effectiveness
- Complexity
- Site Consideration

Impacts to the Red Hill Water Plant are important to the Pearl Harbor Water System, because the Red Hill Water Plant is one of the two primary water plants that provide fresh water to Pearl Harbor. According to NAVFAC Hawaii personnel, the system is configured to automatically start one pump at the Red Hill Water Plant when the water level in tanks S-1 and S-2 drops to a pre-set level. Alternatives that require the water plant to stop operation for a long period will impact the fresh water supply capability for Pearl Harbor.

Cost-effectiveness enables the Water Plant to efficiently satisfy the many needs with limited available capital resources. Due to the limited space at the Red Hill tunnel, the proposed water treatment facility must be located off site. In addition to the treatment facility, pipelines and/or pumps transferring water to and from the treatment facility will be required. Costs were based on June 2009 values. The conceptual estimated costs were prepared for budgetary planning and comparative evaluation purposes.

Complex alternatives can require more effort to implement. Increased complexity can result in a lower factor of safety for accommodating unforeseen occurrences. Additional time and effort may be required if the recommended alternative is unable to accommodate unforeseen occurrences. The recommended alternative should be able to provide treated drinking water with minimum complexity.

Site considerations were evaluated to incorporate the physical requirements and impacts associated with an alternative. Space requirements were compared to space availability. Impacts to neighboring properties were also considered.

Based on the established criteria, a recommended alternative for the water treatment system would be selected.

Alternatives for Treatment System

The existing Red Hill Water Plant is located within a tunnel. Due to the limited space within the tunnel, the proposed treatment facility must be constructed outside the existing water plant. Because the Red Hill Water Plant provides fresh water to the UST site and Tanks S-1 and S-2, locating the proposed treatment facility near the source or at the receiving point was considered desirable. The open area around Tanks S-1 and S-2 is one of the potential areas considered for the water treatment facility. The other potential site is the open area above or below the UST site. Figure 5-1 shows the approximate location of the UST site and the three proposed water treatment facility locations. Alternatives for the water treatment systems considered were primarily based on the proposed location of the water treatment plant.

Alternative 1 - Water Treatment Facility at Halawa Reservoir

Fresh water drawn from Red Hill Water Plant is generally stored in Halawa Reservoir, Tanks S-1 and S-2 before delivery to Pearl Harbor Complex water system. The open space at Halawa site provides sufficient space for the proposed water treatment facility. The preliminary site layout for this alternative is shown on Figure 5-2.

The existing 30-inch transmission main from Red Hill Water Plant is interconnected with water mains from the Halawa Water Plant and the Waiawa Water Plant before reaching Tanks S-1 and S-2 (Engineering Concepts, 2006). Therefore, new pipe lines and modifications of the existing pipelines are required to locate a new water treatment facility at Halawa Reservoir site. The existing 30-inch pipeline would be used to transferring water from the Halawa Water Plant to Tanks S-1 and S-2. A new 30-inch transmission main is required to convey untreated fresh water from the Red Hill Water Plant to the proposed treatment facility. The treated water would be stored in Tanks S-1 and S-2. A new booster system is required to pump treated water to the UST site through approximately 13,500-feet of new 6-inch water line. The new 6-inch water line would be connected to the existing 6-inch supply line at the Red Hill Water Plant. The proposed treatment system schematic is shown on Figure 5-3. Based on the available information, the following facilities would be required for this alternative:

- Water Treatment Facility:
    - One mechanical building;
    - Ten packed tower air strippers sized at 12 feet diameter by 42 feet high; each air stripper equipped with a blower with a 60 HP motor;
    - Three primary GAC and three secondary GAC contactor sized at approximately 24 feet wide by 48 feet long by 25 feet deep each;

FIGURE 5 - 1

SITE LOCATION MAP

EVALUATE TREATMENT TECHNOLOGIES FOR THE RED HILL DRINKING WATER WELL

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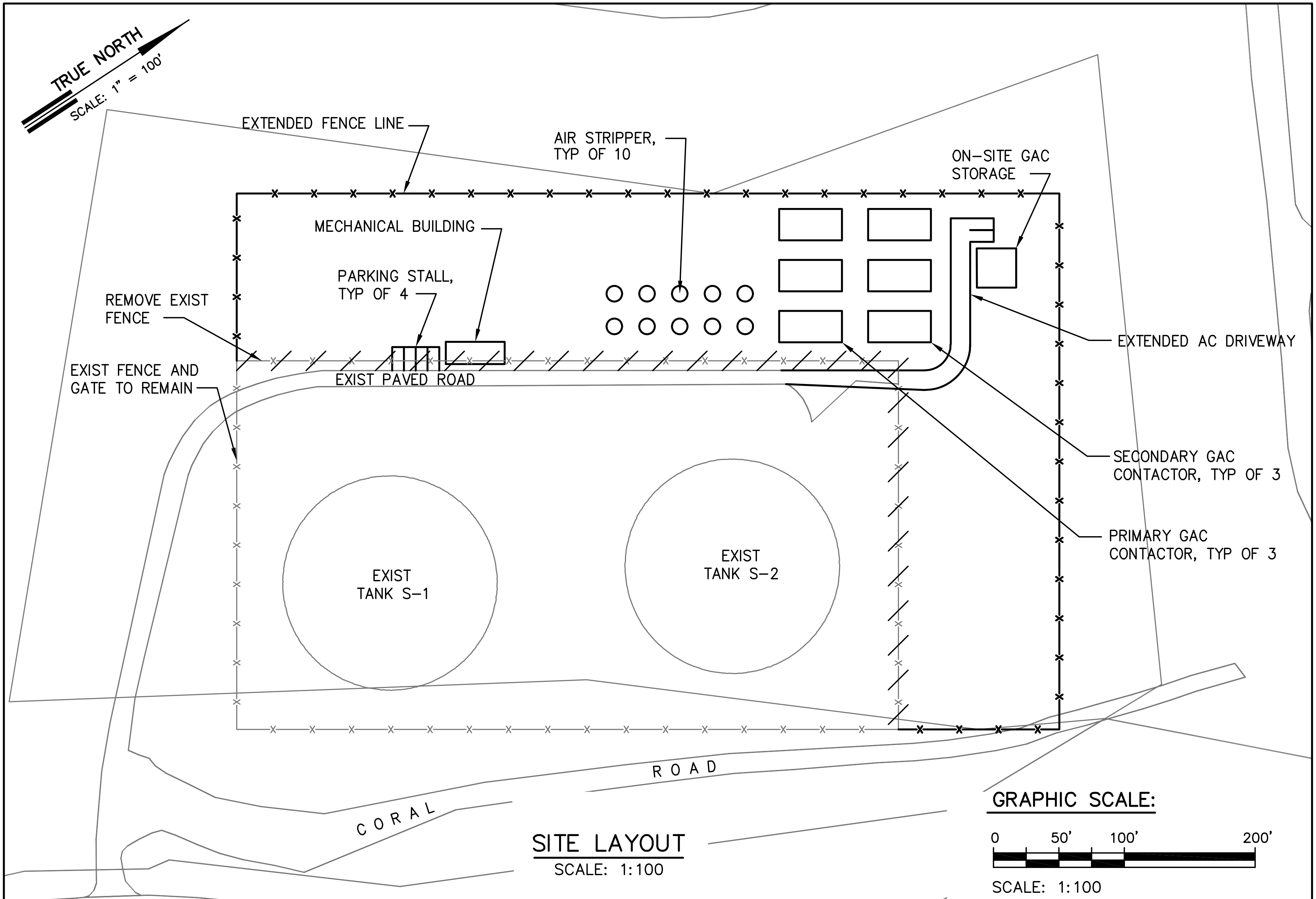

SITE LAYOUT
SCALE: 1:100

HDR HPE Hawaii Pacific Engineers, Inc.	EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII PEARL HARBOR OAHU, HAWAII	RED HILL WATER TREATMENT FACILITY SITE LAYOUT ALTERNATIVE 1	FIGURE 5-2

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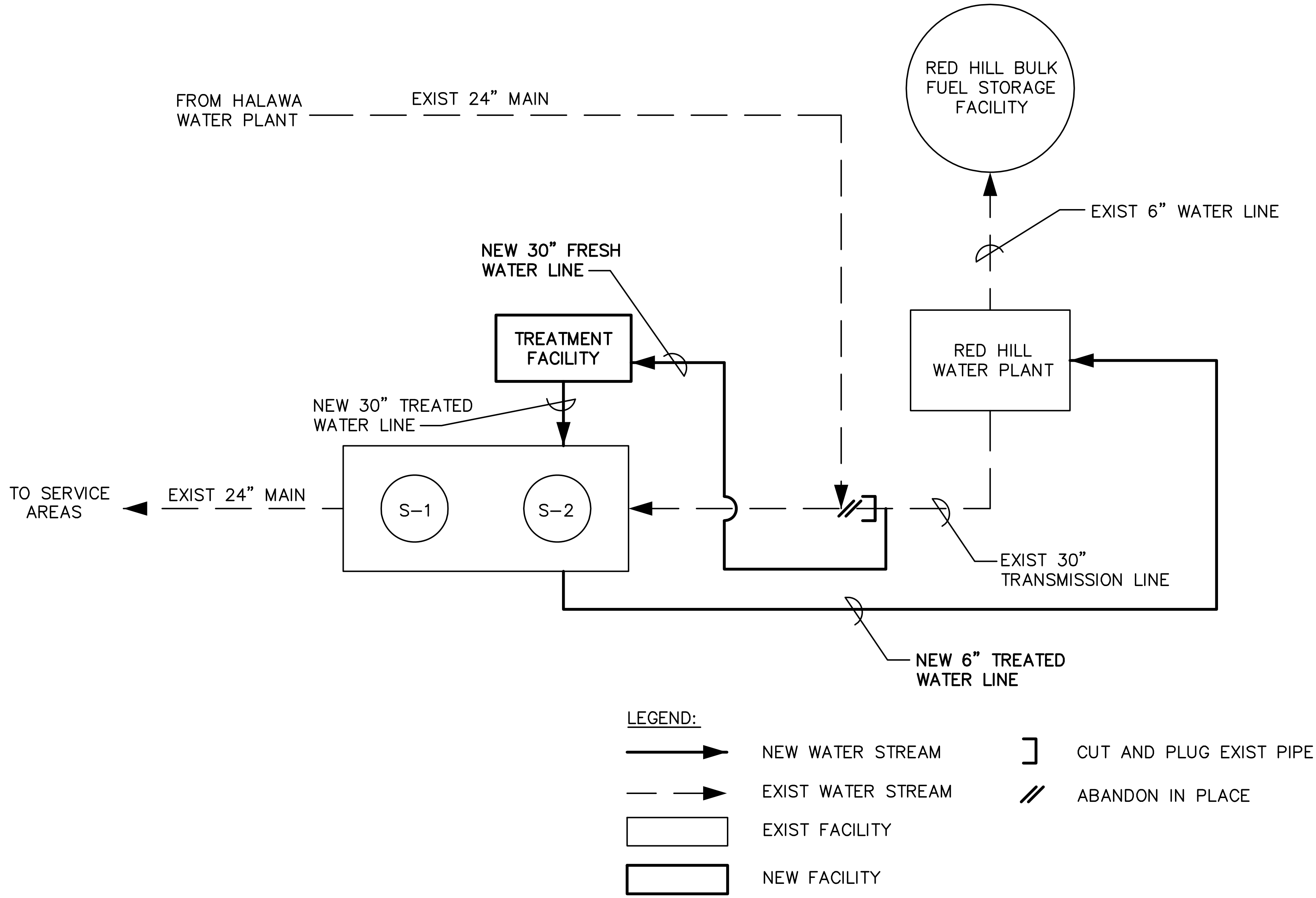

Hawaii Pacific Engineers, Inc.

EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII

PEARL HARBOR OAHU, HAWAII

WATER TREATMENT SYSTEM ALTERNATIVE 1

FIGURE 5–3

    - Three underground clear wells sized at roughly 20 feet wide by 20 feet long by 10 feet deep each;
    - Three pumping systems to pump water from the air stripping clear well to the primary GAC contactors; to pump water from the primary GAC clear well to the secondary GAC contactors; to pump water from the secondary GAC clear well to Tanks S-1 and S-2;
    - AC driveway and parking lots;
    - Chain link fence.
- Approximately 13,500 feet of 6-inch pipeline, and a booster pumping system to transfer water from Tanks S-1 and S-2 to the UST site.
- Approximately 4600 feet 30-inch pipeline.

Table 5-1 presents the estimated construction cost and life cycle cost for Alternative 1.

Table 5-1
Alternative 1 Estimated Capital and Annual O&M Costs

Item	Cost
Capital Cost	
Water Treatment Plant	$ 16,550,000
Booster System	$ 90,000
Water Lines	$ 9,000,000
Electrical and Instrumentation Work	$ 3,000,000
Subtotal	$ 28,640,000
Engineering and Supervision	$4,300,000
Subtotal	$ 32,940,000
Contingency	$ 5,000,000
Subtotal	$ 37,940,000
Bond, 2 percent	$ 760,000
Subtotal	$ 38,700,000
General Excise Tax 4.712 percent	$ 1,900,000
Total Estimated Capital Cost	$ 40,600,000
Total Estimated Capital Cost Rounded	$ 41,000,000
Annual O&M	
Water Treatment Plant	$ 580,000
Activated Carbon Replacement	$ 4,700,000
Pumps and Transmission	30,000
Electrical Power	$ 1,000,000
Total O&M Cost	$ 6,310,000

Because the existing 30-inch transmission main provides water to several housing areas, this alternative cannot be constructed without significant interruption of current system operations.

In addition to disruption of vehicle and pedestrian traffic can be expected during construction of the new 30-inch and 6-inch water lines between Halawa Reservoir and Red Hill.

Alternative 2 – Water Treatment Facility below Red Hill Bulk Fuel Storage Facility

Alternative 2 involves locating the treatment facility at the ground surface in the open area below Red Hill Bulk Fuel Storage Facility. The preliminary facility site layout is shown on Figure 5-4. A new 30-inch water line would be required to deliver fresh water from the water plant to the treatment facility. This alternative stores the treated water in an on-site finished water storage tank, and delivers treated water to Tanks S-1 and S-2 by gravity through another new 30-inch water line connected to the existing 30-inch transmission main at the existing Red Hill pumping facility. The existing 6-inch water line and booster pump system at the Red Hill pump station would continue to be utilized to deliver treated water to the UST site. The proposed treatment system schematic is shown on Figure 5-5.

Hydraulic analysis is required to evaluate the existing facility capacity to draw water from infiltration tunnel and pump the water to the proposed treatment facility site. The hydraulic analysis was performed using a KYPIPE model. Because fresh water from the Red Hill Water Plant would be directly discharged to packed tower strippers under atmospheric pressure, the discharge point of the system can be modeled as a water tank in the KYPIPE model. The KYPIPE model for Alternative 2 consists of 19 pipes, 11 primary nodes, one tank and one supply reservoir. A schematic for the KYPIPE model with pipe and junction node number is included in Appendix D. The KYPIPE model incorporated the following assumptions:

- The infiltration channel of Red Hill Water Plant was assumed to be similar to a single reservoir with the low water level set to 8 feet MSL and high water level set to 19 feet MSL. The estimated discharge elevation of the pipeline is approximately 462 feet MSL.

- The estimated treatment facility elevation is 420 feet.

- The C-factor of the new 30-inch main was set to 130.

- Due to unavailability of pump curves for the four existing pumps, the analysis was based on assuming a constant power of 400 HP at 77 percent efficiency similar to the calibration run in Chapter 3.

Pipe lengths and fitting configurations were based on information from record drawings. The KYPIPE output file is included in Appendix D. The model result indicated that with three pumps running simultaneously, the existing water plant can deliver approximately 10,265 gpm, or 14.79 mgd, of fresh water to the proposed treatment facility site. This is less than the target 16 mgd production rate. Additional model runs were conducted with four vertical turbine pumps running simultaneously. Model results indicated that the water plant is able to operate at the target design capacity when all four pumps are running; however, under this operational mode, the Red Hill Water Plant would not have the required operational redundancy. Therefore, new pumps are required for this alternative.

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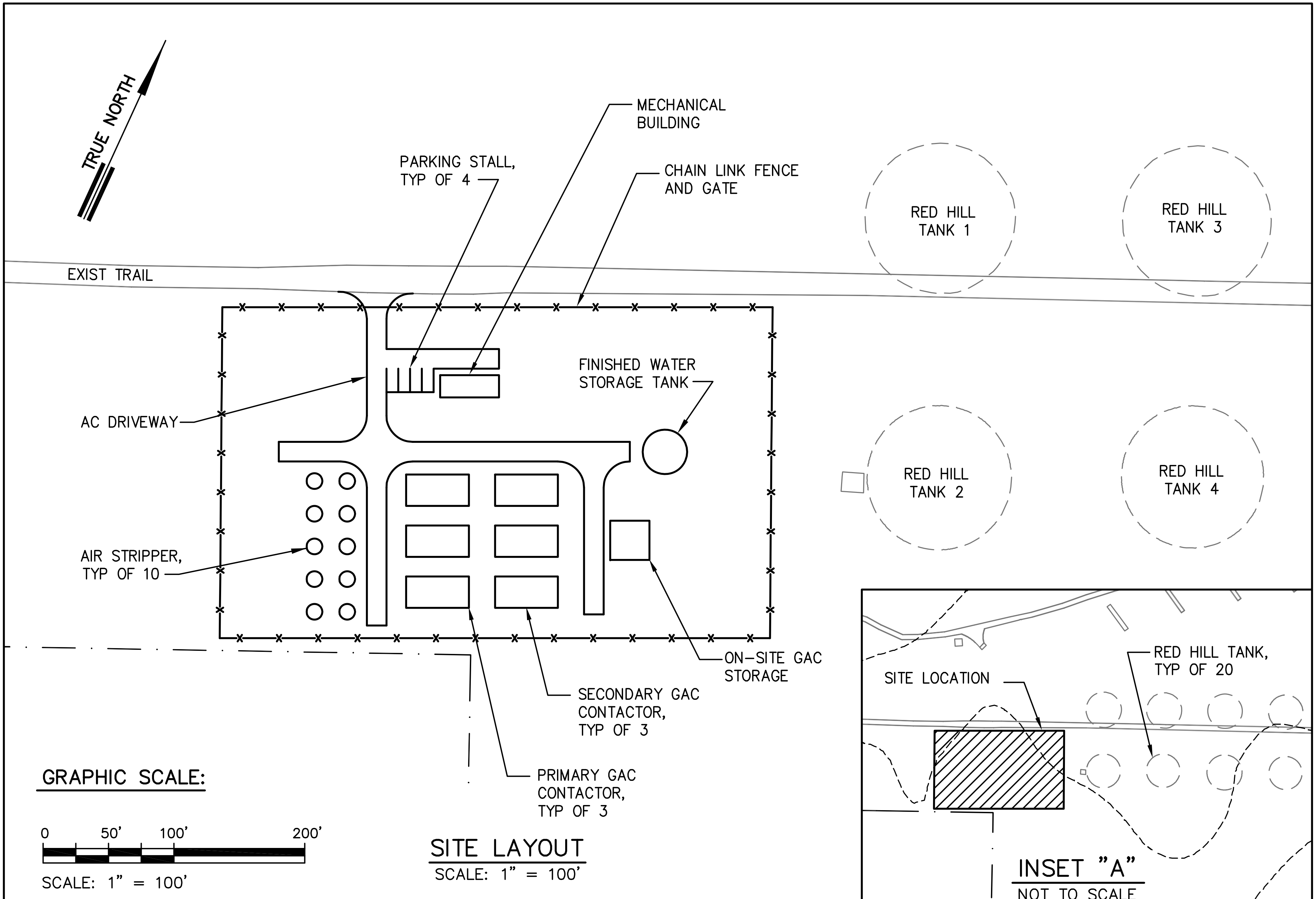
FILE: 2008014–FIG–12 REVISED: 08/11/10



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EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII

PEARL HARBOR OAHU, HAWAII

RED HILL WATER TREATMENT FACILITY SITE LAYOUT ALTERNATIVE 2

FIGURE 5–4

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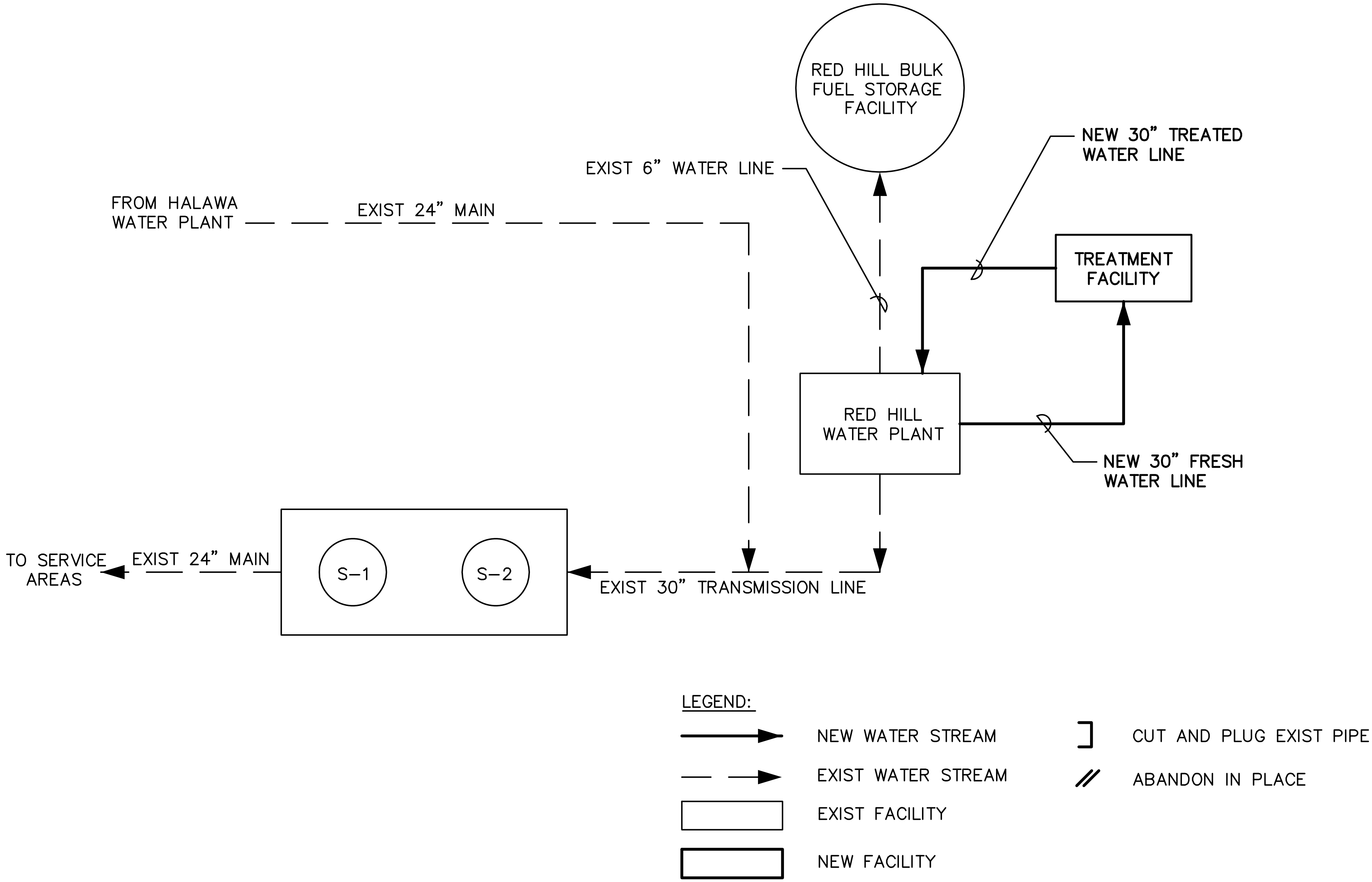

Hawaii Pacific Engineers, Inc.

EVALUATE TREATMENT FOR RED HILL WELL,
PEARL HARBOR, HAWAII

PEARL HARBOR OAHU, HAWAII

WATER TREATMENT SYSTEM
ALTERNATIVE 2

FIGURE
5–5

Two options were considered to transfer water to the proposed treatment facility site. Alternative 2a involves replacing the existing vertical turbine pumps with higher capacity vertical turbine pumps. Alternative 2b involves adding a booster pump system.

Based on the available information, it is estimated that the following facilities would be required for alternative 2a:

- Four 800 HP vertical turbine pumps.
- Two 30-inch pipelines between the Red Hill Water Plant and UST site, each approximately 4800 feet long.
- Water Treatment Facility:
    - One mechanical building;
    - Ten packed tower air strippers sized at 12 feet diameter by 42 feet high; each air stripper quipped with a blower with a 60 HP motor;
    - Three primary GAC and three secondary GAC contactor sized at approximately 24 feet wide by 48 feet long by 25 feet deep each;
    - Three underground clear wells sized at approximately 20 feet wide by 20 feet long by 10 feet deep each;
    - Three pumping systems to pump water from the air stripping clear well to the primary GAC contactors; to pump water from the primary GAC clear well to the secondary GAC contactors; to pump water from the secondary GAC clear well to an on-site storage tank;
    - A 167,000-gallon potable water storage tank sized at roughly 34 feet diameter by 26 feet high.
    - AC driveway and parking lots
    - Chain link fence and gates.

Hydraulic analysis of Alternative 2a with four new vertical turbine pumps was conducted using a KYPIPE model. The KYPIPE output file is included in Appendix D. The model result indicated two vertical turbine pumps operating simultaneously are capable of transferring 11,926 gpm, or 17.19 mgd, of water from the existing water plant to the proposed treatment facility site.

Alternative 2b would be similar to Alternative 2a except that four new booster pumps would be utilized in conjunction with the existing well pumps instead of providing four new, higher horsepower well pumps. The existing well pumps and booster pumps would operate in series to convey water to the water treatment plant site. The operating loads of the existing well pumps and new booster pumps would be substantially higher than the existing electrical loads. Therefore, it was assumed that major electrical power work would be required for Alternative 2b.

Table 5-2 presents the estimated capital and O&M costs for Alternative 2a and Alternative 2b.

Table 5-2
Alternatives 2a and 2b Estimated Capital and Annual O&M Costs

Item	Alternative 2a	Alternative 2b
Capital Cost		
Water Treatment Plant	$ 16,290,000	$ 16,290,000
Vertical Turbine Well Pumps	2,300,000	0
Booster Pump System	$0	$ 1,200,000
Water Lines	$ 3,300,000	$ 3,300,000
Electrical and Instrumentation Work	$ 4,800,000	$ 10,000,000
Subtotal	$ 26,690,000	$ 30,790,000
Engineering and Supervision	$4,100,000	$4,700,000
Subtotal	$ 30,790,000	$ 35,490,000
Contingency	$ 4,700,000	$ 5,400,000
Subtotal	$ 35,490,000	$ 40,890,000
Bond, 2 percent	$ 710,000	$ 820,000
Subtotal	$ 36,200,000	$ 41,710,000
General Excise Tax 4.712 percent	$ 1,800,000	$ 2,000,000
Total Estimated Capital Cost	$ 38,000,000	$ 43,710,000
Total Estimated Capital Cost Rounded	$ 38,000,000	$ 44,000,000
Annual O&M		
Water Treatment Plant	$ 580,000	$ 580,000
Activated Carbon Replacement	$ 4,700,000	$ 4,700,000
Pumps and Transmission	20,000	20,000
Electrical Power	$ 1,400,000	$ 1,500,000
Total O&M Cost	$ 6,700,000	$ 6,800,000

Alternative 3 – Water Treatment Facility above Red Hill Bulk Fuel Storage Facility

Alternative 3 involves locating the treatment facility at the ground surface in the open area above the Red Hill Bulk Fuel Storage Facility. The proposed treatment facility layout is shown on Figure 5-6. A new 30-inch pipeline would be required to deliver fresh water from the existing water plant to the treatment facility. The treated water would be stored in an on-site finished water storage tank. Treated water would be delivered to Tanks S-1 and S-2 by gravity through another new 30-inch water line connected to the existing 30-inch transmission main at the existing water plant. Water supply to the UST site would be provided by a new 6-inch water line. The system schematic is shown on Figure 5-7.

Because Alternative 3 proposes to locate the treatment facility at a higher elevation than Alternative 2, it is known that the existing vertical turbine pumps do not have sufficient capacity. Therefore, new pumps are required for this alternative. There are two options to transfer the groundwater to the proposed treatment facility site. Alternative 3a involves replacing the existing vertical turbine pumps with higher capacity vertical turbine pumps. Alternative 3b involves adding a booster pump system to augment the capacity of the existing vertical turbine pumps.

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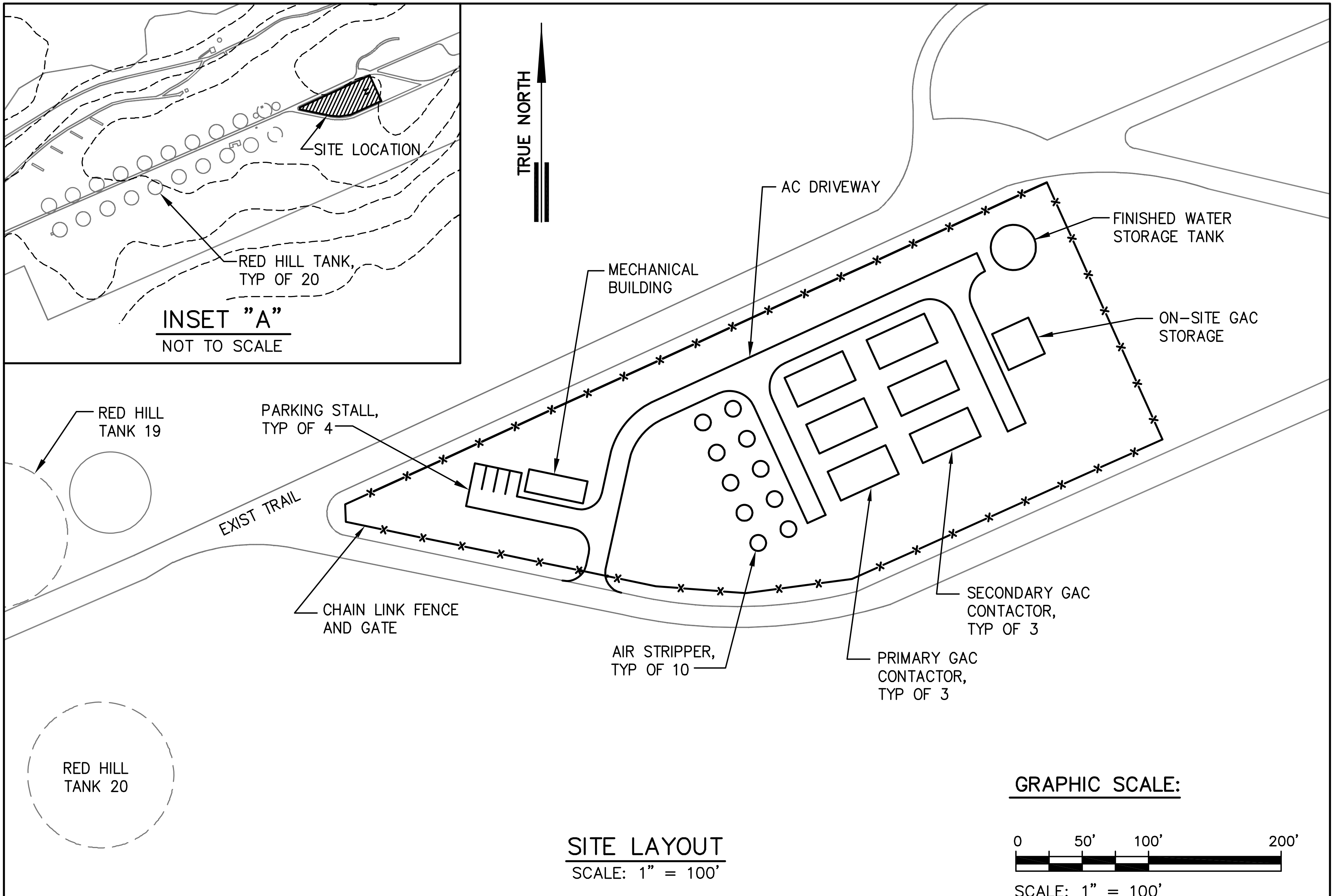
FILE: 2008014-FIG-05 REVISED: –



SITE LAYOUT

SCALE: 1" = 100'

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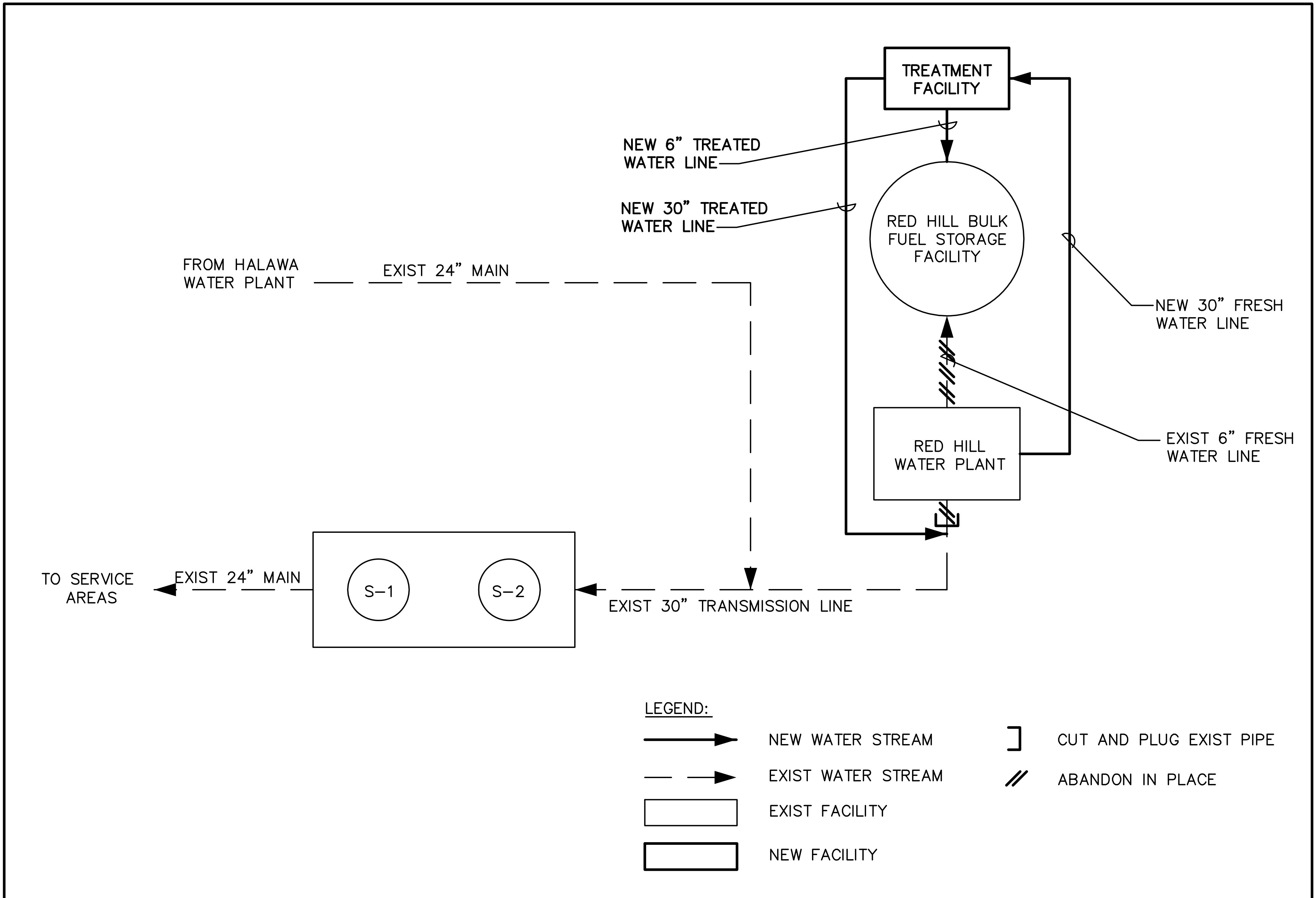
EVALUATE TREATMENT FOR RED HILL WELL, PEARL HARBOR, HAWAII

PEARL HARBOR OAHU, HAWAII

RED HILL WATER TREATMENT FACILITY SITE LAYOUT ALTERNATIVE 3

FIGURE 5–6

DATE: 06/10/09 PM: FTH
SCALE: 1 = 1 OPER: HC
FILE: 2008014-FIG-11 REVISED: –



Hawaii Pacific Engineers, Inc.

EVALUATE TREATMENT FOR RED HILL WELL,
PEARL HARBOR, HAWAII

PEARL HARBOR OAHU, HAWAII

WATER TREATMENT SYSTEM
ALTERNATIVE 3

FIGURE
5–7

Based on the available information, it is estimated that the following facilities would be required for Alternative 3a:

- Four 1250 HP vertical turbine pumps.
- Two 30-inch pipelines between the Red Hill Water Plant and the UST site, each of approximately 4800 feet long.
- Water Treatment Facility:
    - One mechanical building;
    - Ten packed tower air strippers sized at 12 feet diameter by 42 feet high; each air stripper equipped with a blower with a 60 HP motor;
    - Three primary GAC and three secondary GAC contactors sized at approximately 24 feet wide by 48 feet long by 25 feet deep each;
    - Three underground clear wells sized at approximately 20 feet wide by 20 feet long by 10 feet deep each;
    - Three pumping systems to pump water from the air stripping clear well to the primary GAC contactors; to pump water from the primary GAC clear well to the secondary GAC contactors; to pump water from the secondary GAC clear well to an on-site storage tank;
    - A 167,000-gallon potable water storage tank sized at approximately 34 feet diameter by 26 feet high;
    - AC driveway and parking lots.
- Approximately 200-feet of 6-inch pipeline to deliver treated water to the fuel storage facility by gravity.

Hydraulic analysis of the four new vertical turbine pumps under Alternative 3a was conducted using a KYPIPE model and is included in Appendix D. The KYPIPE model consists of 19 pipes, 11 primary nodes, one tank, and one supply reservoir. Pipe lengths and fittings were estimated from information on record drawings. The KYPIPE model incorporated the following assumptions:

- The infiltration channel of Red Hill Water Plant is similar to a single reservoir, with low water level set to 8 feet MSL, and high water level set to 19 feet MSL. The estimated discharge elevation of the pipeline is approximately 632 feet MSL.

- The estimated treatment facility elevation is 590 feet.

- The C-factor of the new 30-inch main was set to 130.

The model result indicated the vertical turbine pumps can supply water at the target production rate of 16 mgd to the proposed treatment facility site. The model result also indicated that three of the four vertical turbine pumps are needed to pump 16 mgd to the proposed treatment facility site.

Alternative 3b would be similar to Alternative 3a except that four new booster pumps would be utilized in conjunction with the existing well pumps instead of providing four new, higher horsepower well pumps. The existing well pumps and booster pumps would operate in series to convey water to the water treatment plant site. The operating loads of the existing well pumps and new booster pumps would be substantially higher than the existing electrical loads. Therefore, it was assumed that major electrical power work would also be required for Alternative 3b.

Table 5-3 presents the estimated capital and O&M costs for Alternative 3a and Alternative 3b.

Table 5-3
Alternatives 3a and 3b Estimated Capital and Annual O&M Costs

Item	Alternative 3a	Alternative 3b
Capital Cost		
Water Treatment Plant	$ 16,190,000	$ 16,190,000
Vertical Turbine Well Pumps	2,700,000	0
Booster Pump System	$0	$ 1,500,000
Water Lines	$ 5,600,000	$ 5,600,000
Electrical and Instrumentation Work	$ 10,900,000	$ 12,600,000
Subtotal	$ 35,390,000	$ 35,890,000
Engineering and Supervision	$5,400,000	$5,400,000
Subtotal	$ 40,790,000	$ 41,290,000
Contingency	$ 6,200,000	$ 6,200,000
Subtotal	$ 46,990,000	$ 47,490,000
Bond, 2 percent	$ 940,000	$ 950,000
Subtotal	$ 47,930,000	$ 48,440,000
General Excise Tax 4.712 percent	$ 2,300,000	$ 2,300,000
Total Estimated Capital Cost	$ 50,230,000	$ 50,740,000
Total Estimated Capital Cost Rounded	$ 50,000,000	$ 51,000,000
Annual O&M		
Water Treatment Plant	$ 580,000	$ 580,000
Activated Carbon Replacement	$ 4,700,000	$ 4,700,000
Pumps and Transmission	30,000	20,000
Electrical Power	$ 1,400,000	$ 1,500,000
Total O&M Cost	$ 7,010,000	$ 7,000,000

Summary and Recommendations

This study has presented three alternative systems. The three alternatives involve locating the treatment facility at the Halawa Reservoir site, locating the treatment facility at ground level at the lower elevation side of the Red Hill Bulk Fuel Storage site, and locating the treatment facility at ground level at the higher elevation side of the Red Hill Bulk Fuel Storage Facility site. Alternative 2 and Alternative 3 involve simpler piping system modifications as compared to Alternative 1. These two alternatives would only require equipment and pipeline modifications within the Red Hill Water Plant and construction of two new 30-inch pipe lines to convey water to and from the treatment facility. The new pipe line construction under Alternatives 2 and 3 also has less potential for interruption of existing water system operation than Alternative 1.

The estimated capital cost, operation and maintenance cost, and life-cycle cost for the three alternatives are summarized below and are also included in Appendix C. For the life cycle cost analysis, the alternative system components were estimated to have the economic useful life expectancy as shown in Table 5-4. Annual power cost was based on an electricity charge of $0.19 per kilowatt hour.

Table 5-4
Typical Equipment Life Expectancy*

Equipment	Life Expectancy in Years
GAC contactors	50
Clear Well	50
Tanks	50
Air Strippers	10
Blowers & Pumps	10

*Based on EPA publication EPA 816-R-03-016 (Appendix E).

Life cycle costs were based on an analysis period of 50-years, which is equivalent to the anticipated useful life of the treatment facility. The existing vertical turbine pumps and boosters were assumed to be installed in the year 2004 for the projecting existing equipment replacement. A discount factor of 2.8 percent was utilized in accordance with Office of Management and Budget (OMB) Circular A-94 for long-term economic analysis for military construction projects.

Table 5-5
Summary of Comparative Evaluation of Treatment System Alternatives

Item	Alternative 1	Alternative 2a	2b	Alternative 3a	3b
Capital Cost	$ 41,000,000	$ 38,000,000	$ 44,000,000	$ 50,000,000	$ 51,000,000
Annual O&M Cost	$ 6,310,000	$ 6,700,000	$ 6,800,000	$ 7,010,000	$ 7,000,000
Life Cycle Cost 50-yr	$ 243,533,946	$ 250,790,248	$ 263,053,587	$ 274,616,725	$ 277,377,699
Impact to Existing Facilities	High	Moderate	High	High	High
Complexity	High	Moderately Low	High	Moderately High	High
Site Consideration	Fair	Very Good	Very Good	Very Good	Very Good

The life cycle cost of Alternative 1 is the lowest among the alternatives considered. The estimated capital cost of Alternative 1 is the second lowest among the alternatives considered and its estimated annual operation and maintenance cost is the lowest among the alternatives considered. However, Alternative 1 has a high impact to existing facilities and is considered to be highly complex because of the complexity of the interconnections between the transmission and distribution piping systems. The site considerations factor for the water treatment plant location under Alternative 1 is considered to be fair because of the proximity to existing residential areas.

The life cycle cost of Alternative 2a is about 3 percent higher than Alternative 1. The estimated capital cost of Alternative 2a is the lowest among the alternatives considered and its estimated annual operation and maintenance cost is the second lowest among the alternatives considered. Alternative 2a is considered to have moderate impact to existing facilities because the new facilities would simply replace or would simply be added to existing facilities. Alternative 2a is considered to have a moderately low degree of complexity because the simplicity of operation with the existing systems.   The site considerations factor for Alternative 2a is considered to be very good because the water treatment plant site would be isolated from residential and other public areas.

Alternative 2b, Alternative 3a, and Alternative 3b have significantly higher life cycle and estimated capital costs than Alternative 1 and Alternative 2. Alternatives 2b, 3a, and 3b are considered to have a high degree of complexity primarily because major electrical power system modifications required. In addition, Alternatives 2b and 3b would require operation of the existing well pumps and new booster pump systems to be coordinated because the two systems would need to operate simultaneously to transfer water to the respective treatment plant sites.

Based on assessment of the evaluation criteria, Alternative 2a was considered to be the most cost-effective system. Alternative 2a has the second lowest life cycle cost, the lowest capital cost, a simpler design and operating strategy, and less impact to existing Pearl Harbor Complex water system. Alternative 2a is considered to be the most cost effective alternative among the systems evaluated.

Chapter 6

Summary and Recommendations

Chapter 6
Summary and Recommendations

General

This chapter presents recommendations for treating petroleum contaminated groundwater for Red Hill Water Plant. The recommendations were based on the estimated maximum influent concentration and the design capacity of Red Hill Water Plant. Recommended treatment technologies were integrated to formulate an implementation plan. A recommended treatment system is presented. Estimated probable construction, and operation and maintenance cost are provided for the recommended alternative system.

Summary and Recommendations

The U.S. Navy Red Hill Bulk Fuel Storage Facility consists of 18 active and 2 inactive underground storage tanks (UST). Records indicate that several USTs were repaired and have released petroleum to the environment. The facility is located approximately 100 ft above the basal groundwater table, and the released petroleum has a potential to contaminant the groundwater beneath the facility. As part of a comprehensive environmental investigation and risk assessment, quarterly groundwater sampling has been conducted since 2005. Groundwater samples were analyzed for petroleum constituents and compared against the HDOH EALs. Groundwater sampling reports indicated that total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs) and lead have been detected in the groundwater beneath the facility.

The U.S. Navy Red Hill Water Plant, located approximately 3,000 feet down-gradient from USTs, draws water from a submerged infiltration tunnel which extends approximately 1280 feet across the groundwater table (TEC, 2007). The water plant provides approximately 24 percent of the potable water supply to the Pearl Harbor Water System. This purpose of this study is to investigate the treatment technologies for removing dissolved petroleum contaminants from groundwater, and to develop a recommend a treatment system.

According to USEPA, granular activated carbon (GAC) is the BAT for the majority of organic contaminants. Both GAC and air stripping are considered the BATs for the removal of VOCs by the USEPA. The combination of air stripping and GAC has been proven to prolong GAC bed life, and is considered to be more cost-effective than using GAC alone as the treatment technology.

Due to limited space within the Red Hill tunnel, the proposed water treatment facility must be located outside the tunnel. Three site locations were identified for the treatment facility. Alternative 1 involves locating the treatment facility at the existing Halawa Reservoir, Tanks S-1 and S-2. Alternative 2 involves locating the treatment facility at the ground surface below the UST site. Alternative 3 involves locating the treatment facility at the ground surface above the UST site. Hydraulic analyses and cost evaluations were conducted for each alternative, including a life cycle cost comparison. Based on the comparative evaluations, Alternative 2a was selected as the recommended alternative. Alternative 2a has the lowest life cycle cost and second lowest capital cost among the feasible alternatives.

Based on the available information, it is estimated that the following facilities would be required for Alternative 2a:

- Four 800 HP vertical turbine pumps.
- Two 30-inch pipelines between the Red Hill Water Plant and UST site, each approximately 4800 feet long.
- Water Treatment Facility:
    - One mechanical building;
    - Ten packed tower air strippers sized at 12 feet diameter by 42 feet high; each air stripper quipped with a blower with a 60 HP motor;
    - Three primary GAC and three secondary GAC contactor sized at approximately 24 feet wide by 48 feet long by 25 feet deep each;
    - Three underground clear well sized at approximately 20 feet wide by 20 feet long by 10 feet deep each;
    - Three pumping systems to pump water from the air stripping clear well to the primary GAC contactors; to pump water from the primary GAC clear well to the secondary GAC contactors; to pump water from the secondary GAC clear well to an on-site storage tank;
    - A 167,000-gallon potable water storage tank sized at roughly 34 feet diameter by 26 feet high.
    - AC driveway and parking lots
    - Chain link fence and gates.

Programming and construction of the treatment facility should be initiated if either of the treatment facility action levels below are reached.

RHMW01	TPH greater than or equal to 2000 µg/L
RHMW02	TPH greater than or equal to 4500 µg/L for an extended time or if a light non-aqueous phase liquid plume is observed

It is also recommended that at least one additional monitoring well be constructed down-gradient from the Red Hill Bulk Fuel Storage facility, between RHMW01 and the Red Hill Well infiltration tunnel. The purpose of the well would be to provide data to better assess whether the potential contaminants are migrating towards the Red Hill Well, whether attenuation of contaminant concentrations is occurring, and the net rate of contaminant migration towards the Red Hill Well.

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Appendices

Appendix A

Federal and State Regulations

TABLE D-1a. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS located within 150 meters of release site)
(ug/l)

CONTAMINANT	[1] Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
ACENAPHTHENE	2.0E+01	Gross Contamination	2.0E+01	3.7E+02	3.9E+03	2.3E+01
ACENAPHTHYLENE	3.0E+01	Aquatic Habitat Goal	2.0E+03	2.4E+02	(Use soil gas)	3.0E+01
ACETONE	1.5E+03	Aquatic Habitat Goal	2.0E+04	2.2E+04	4.4E+08	1.5E+03
ALDRIN	4.0E-03	Drinking Water Toxicity	8.5E+00	4.0E-03		1.3E-01
AMETRYN	1.5E+01	Aquatic Habitat Goal	5.0E+04	3.3E+02		1.5E+01
AMINO,2- DINITROTOLUENE,4,6-	1.5E+01	Aquatic Habitat Goal	5.0E+04	7.3E+01		1.5E+01
AMINO,4- DINITROTOLUENE,2,6-	1.5E+01	Aquatic Habitat Goal	5.0E+04	7.3E+01		1.5E+01
ANTHRACENE	7.3E-01	Aquatic Habitat Goal	2.2E+01	1.8E+03	4.3E+01	7.3E-01
ANTIMONY	6.0E+00	Drinking Water Toxicity	5.0E+04	6.0E+00		3.0E+01
ARSENIC	1.0E+01	Drinking Water Toxicity	5.0E+04	1.0E+01		3.6E+01
ATRAZINE	3.0E+00	Drinking Water Toxicity	1.7E+04	3.0E+00		1.2E+01
BARIUM	2.0E+03	Aquatic Habitat Goal	5.0E+04	2.0E+03		2.0E+03
BENZENE	5.0E+00	Drinking Water Toxicity	1.7E+02	5.0E+00	1.5E+03	4.6E+01
BENZO(a)ANTHRACENE	2.7E-02	Aquatic Habitat Goal	4.7E+00	9.2E-02		2.7E-02
BENZO(a)PYRENE	1.4E-02	Aquatic Habitat Goal	8.1E-01	2.0E-01		1.4E-02
BENZO(b)FLUORANTHENE	9.2E-02	Aquatic Habitat Goal	7.5E-01	9.2E-02		9.2E-02
BENZO(g,h,i)PERYLENE	1.0E-01	Aquatic Habitat Goal	1.3E-01	1.5E+03		1.0E-01
BENZO(k)FLUORANTHENE	4.0E-01	Gross Contamination	4.0E-01	9.2E-01		3.7E+00
BERYLLIUM	2.7E+00	Aquatic Habitat Goal	5.0E+04	4.0E+00		2.7E+00
BIPHENYL, 1,1-	5.0E-01	Gross Contamination	5.0E-01	3.0E+02	(Use soil gas)	1.4E+01
BIS(2-CHLOROETHYL)ETHER	1.2E-02	Drinking Water Toxicity	3.6E+02	1.2E-02	1.1E+02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	3.2E-01	Drinking Water Toxicity	3.2E+02	3.2E-01	(Use soil gas)	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	6.0E+00	Drinking Water Toxicity	1.4E+02	6.0E+00		3.2E+01
BORON	4.1E+01	Drinking Water Toxicity	5.0E+04	4.1E+01		7.3E+03
BROMODICHLOROMETHANE	2.2E-01	Drinking Water Toxicity	5.0E+04	2.2E-01	1.6E+02	3.2E+03
BROMOFORM	1.0E+02	Drinking Water Toxicity	5.1E+02	1.0E+02		3.2E+03
BROMOMETHANE	8.7E+00	Drinking Water Toxicity	5.0E+04	8.7E+00	3.6E+02	1.6E+02
CADMIUM	3.0E+00	Aquatic Habitat Goal	5.0E+04	5.0E+00		3.0E+00
CARBON TETRACHLORIDE	5.0E+00	Drinking Water Toxicity	5.2E+02	5.0E+00	3.1E+01	9.8E+00
CHLORDANE (TECHNICAL)	4.0E-03	Aquatic Habitat Goal	2.5E+00	2.0E+00		4.0E-03
CHLOROANILINE, p-	1.2E+00	Drinking Water Toxicity	5.0E+04	1.2E+00		5.0E+00
CHLOROBENZENE	2.5E+01	Aquatic Habitat Goal	5.0E+01	1.0E+02	9.6E+03	2.5E+01
CHLOROETHANE	1.6E+01	Gross Contamination	1.6E+01	8.6E+03	4.4E+05	1.2E+04
CHLOROFORM	7.0E+01	Drinking Water Toxicity	2.4E+03	7.0E+01	7.4E+01	6.2E+02
CHLOROMETHANE	1.8E+00	Drinking Water Toxicity	5.0E+04	1.8E+00	2.9E+02	3.2E+03
CHLOROPHENOL, 2-	1.8E-01	Gross Contamination	1.8E-01	3.0E+01	5.8E+04	1.4E+02
CHROMIUM (Total)	7.4E+01	Aquatic Habitat Goal	5.0E+04	1.0E+02		7.4E+01
CHROMIUM III	7.4E+01	Aquatic Habitat Goal	5.0E+04	5.5E+04		7.4E+01
CHROMIUM VI	2.1E-01	Drinking Water Toxicity	5.0E+04	2.1E-01		1.1E+01
CHRYSENE	3.5E-01	Aquatic Habitat Goal	1.0E+00	9.2E+00		3.5E-01
COBALT	4.2E-02	Drinking Water Toxicity	5.0E+04	4.2E-02		3.0E+00
COPPER	2.9E+00	Aquatic Habitat Goal	1.0E+03	1.3E+03		2.9E+00
CYANIDE (Free)	1.0E+00	Aquatic Habitat Goal	1.7E+02	2.0E+02	(Use soil gas)	1.0E+00
CYCLO-1,3,5-TRIMETHYLENE-2,4,6-TRINITRAMINE (RDX)	6.1E-01	Drinking Water Toxicity	3.0E+04	6.1E-01		1.9E+02
DALAPON	2.0E+02	Drinking Water Toxicity	5.0E+04	2.0E+02		3.0E+02

TABLE D-1a. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS located within 150 meters of release site)
(ug/l)

CONTAMINANT	[1] Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
DIBENZO(a,h)ANTHTRACENE	9.2E-03	Drinking Water Toxicity	5.2E-01	9.2E-03		7.5E+00
DIBROMO,1,2- CHLOROPROPANE,3-	4.0E-02	Aquatic Habitat Goal	1.0E+01	4.0E-02	(Use soil gas)	4.0E-02
DIBROMOCHLOROMETHANE	1.6E-01	Drinking Water Toxicity	5.0E+04	1.6E-01	2.7E+02	3.2E+03
DIBROMOETHANE, 1,2-	6.5E-03	Drinking Water Toxicity	5.0E+04	6.5E-03	1.2E+01	1.4E+03
DICHLOROBENZENE, 1,2-	1.0E+01	Gross Contamination	1.0E+01	6.0E+02	6.5E+04	1.4E+01
DICHLOROBENZENE, 1,3-	6.5E+01	Aquatic Habitat Goal	5.0E+04	1.8E+02	(Use soil gas)	6.5E+01
DICHLOROBENZENE, 1,4-	5.0E+00	Gross Contamination	5.0E+00	7.5E+01	3.0E+02	1.5E+01
DICHLOROBENZIDINE, 3,3-	1.5E-01	Drinking Water Toxicity	1.6E+03	1.5E-01		2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	1.0E-03	Aquatic Habitat Goal	4.5E+01	2.8E-01		1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.0E-03	Aquatic Habitat Goal	2.0E+01	2.0E-01		1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.0E-03	Aquatic Habitat Goal	2.8E+00	2.0E-01		1.0E-03
DICHLOROETHANE, 1,1-	2.4E+00	Drinking Water Toxicity	5.0E+04	2.4E+00	7.4E+02	4.7E+01
DICHLOROETHANE, 1,2-	1.5E-01	Drinking Water Toxicity	7.0E+03	1.5E-01	1.2E+02	1.0E+04
DICHLOROETHYLENE, 1,1-	7.0E+00	Drinking Water Toxicity	1.5E+03	7.0E+00	5.1E+03	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	7.0E+01	Drinking Water Toxicity	5.0E+04	7.0E+01	4.3E+03	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	1.0E+02	Drinking Water Toxicity	2.6E+02	1.0E+02	3.9E+03	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E-01	Gross Contamination	3.0E-01	1.1E+02		1.8E+02
DICHLOROPHENOXYACETIC ACID (2,4-D)	4.0E+01	Aquatic Habitat Goal	5.0E+04	7.0E+01		4.0E+01
DICHLOROPROPANE, 1,2-	5.0E+00	Drinking Water Toxicity	1.0E+01	5.0E+00	2.1E+02	1.5E+03
DICHLOROPROPENE, 1,3-	4.3E-01	Drinking Water Toxicity	5.0E+04	4.3E-01	4.4E+02	1.2E+02
DIELDRIN	1.9E-03	Aquatic Habitat Goal	4.1E+01	4.2E-03		1.9E-03
DIETHYLPHTHALATE	1.5E+00	Aquatic Habitat Goal	5.0E+04	2.9E+04		1.5E+00
DIMETHYLPHENOL, 2,4-	1.1E+02	Aquatic Habitat Goal	4.0E+02	1.2E+02	1.2E+06	1.1E+02
DIMETHYLPHTHALATE	1.5E+00	Aquatic Habitat Goal	5.0E+04	2.0E+04		1.5E+00
DINITROBENZENE, 1,3-	3.7E+00	Drinking Water Toxicity	5.0E+04	3.7E+00		3.0E+01
DINITROPHENOL, 2,4-	7.3E+01	Drinking Water Toxicity	5.0E+04	7.3E+01		7.5E+01
DINITROTOLUENE, 2,4- (2,4-DNT)	4.4E+01	Aquatic Habitat Goal	5.0E+04	7.3E+01		4.4E+01
DINITROTOLUENE, 2,6- (2,6-DNT)	3.7E+01	Drinking Water Toxicity	5.0E+04	3.7E+01		4.4E+01
DIOXANE, 1,4-	6.1E+00	Drinking Water Toxicity	5.0E+04	6.1E+00		3.4E+05
DIOXINS (TEQ)	5.0E-06	Aquatic Habitat Goal	6.0E-02	3.0E-05		5.0E-06
DIURON	6.0E+01	Aquatic Habitat Goal	2.1E+04	7.3E+01		6.0E+01
ENDOSULFAN	8.7E-03	Aquatic Habitat Goal	2.3E+02	2.2E+02		8.7E-03
ENDRIN	2.3E-03	Aquatic Habitat Goal	4.1E+01	2.0E+00		2.3E-03
ETHANOL	5.0E+04	Gross Contamination	5.0E+04			
ETHYLBENZENE	3.0E+01	Gross Contamination	3.0E+01	7.0E+02	5.2E+03	2.9E+02
FLUORANTHENE	8.0E+00	Aquatic Habitat Goal	1.3E+02	1.5E+03		8.0E+00
FLUORENE	3.9E+00	Aquatic Habitat Goal	9.5E+02	2.4E+02	1.9E+03	3.9E+00
GLYPHOSATE	6.5E+01	Aquatic Habitat Goal	5.0E+04	7.0E+02		6.5E+01
HEPTACHLOR	3.6E-03	Aquatic Habitat Goal	2.0E+01	4.0E-01		3.6E-03
HEPTACHLOR EPOXIDE	3.6E-03	Aquatic Habitat Goal	1.0E+02	2.0E-01		3.6E-03
HEXACHLOROBENZENE	1.0E+00	Drinking Water Toxicity	3.1E+00	1.0E+00		3.7E+00
HEXACHLOROBUTADIENE	8.6E-01	Drinking Water Toxicity	6.0E+00	8.6E-01		4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	8.0E-02	Aquatic Habitat Goal	4.0E+03	2.0E-01		8.0E-02
HEXACHLOROETHANE	4.8E+00	Drinking Water Toxicity	1.0E+01	4.8E+00		1.2E+01
HEXAZINONE	1.2E+03	Drinking Water Toxicity	5.0E+04	1.2E+03		5.0E+03

TABLE D-1a. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS located within 150 meters of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
INDENO(1,2,3-cd)PYRENE	9.2E-02	Aquatic Habitat Goal	9.5E-02	9.2E-02		9.2E-02
ISOPHORONE	7.1E+01	Drinking Water Toxicity	5.0E+04	7.1E+01		1.3E+02
LEAD	5.6E+00	Aquatic Habitat Goal	5.0E+04	1.5E+01		5.6E+00
MERCURY	2.5E-02	Aquatic Habitat Goal	3.0E+01	2.0E+00	(Use soil gas)	2.5E-02
METHOXYCHLOR	3.0E-02	Aquatic Habitat Goal	5.0E+01	4.0E+01		3.0E-02
METHYL ETHYL KETONE	7.1E+03	Drinking Water Toxicity	8.4E+03	7.1E+03	1.5E+08	1.4E+04
METHYL ISOBUTYL KETONE	1.7E+02	Aquatic Habitat Goal	1.3E+03	2.0E+03	1.9E+07	1.7E+02
METHYL MERCURY	3.0E-03	Aquatic Habitat Goal	5.0E+04	3.7E+00		3.0E-03
METHYL TERT BUTYL ETHER	5.0E+00	Gross Contamination	5.0E+00	1.2E+01	2.1E+04	1.8E+04
METHYLENE CHLORIDE	4.8E+00	Drinking Water Toxicity	9.1E+03	4.8E+00	3.1E+03	2.2E+03
METHYLNAPHTHALENE, 1-	2.1E+00	Aquatic Habitat Goal	1.0E+01	4.7E+00	1.1E+04	2.1E+00
METHYLNAPHTHALENE, 2-	2.1E+00	Aquatic Habitat Goal	1.0E+01	2.4E+01	2.5E+04	2.1E+00
MOLYBDENUM	1.8E+02	Drinking Water Toxicity	5.0E+04	1.8E+02		2.4E+02
NAPHTHALENE	1.7E+01	Drinking Water Toxicity	2.1E+01	1.7E+01	2.5E+03	2.4E+01
NICKEL	5.0E+00	Aquatic Habitat Goal	5.0E+04	1.0E+02		5.0E+00
NITROBENZENE	3.4E+00	Drinking Water Toxicity	5.0E+04	3.4E+00	(Use soil gas)	6.0E+01
NITROGLYCERIN	3.7E+00	Drinking Water Toxicity	5.0E+04	3.7E+00		1.4E+02
NITROTOLUENE, 2-	6.2E-02	Drinking Water Toxicity	5.0E+04	6.2E-02	(Use soil gas)	1.0E+03
NITROTOLUENE, 3-	1.2E+02	Drinking Water Toxicity	5.0E+04	1.2E+02	(Use soil gas)	3.8E+02
NITROTOLUENE, 4-	4.2E+00	Drinking Water Toxicity	5.0E+04	4.2E+00		1.6E+03
PENTACHLOROPHENOL	1.0E+00	Drinking Water Toxicity	3.0E+01	1.0E+00		7.9E+00
PENTAERYTHRITOLTETRANITRATE (PETN)	6.1E-01	Drinking Water Toxicity	2.2E+04	6.1E-01		8.5E+04
PERCHLORATE	2.6E+01	Drinking Water Toxicity	5.0E+04	2.6E+01		6.0E+02
PHENANTHRENE	4.6E+00	Aquatic Habitat Goal	4.1E+02	2.4E+02	(Use soil gas)	4.6E+00
PHENOL	5.0E+00	Gross Contamination	5.0E+00	4.0E+02		1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	1.4E-02	Aquatic Habitat Goal	1.6E+01	5.0E-01		1.4E-02
PROPICONAZOLE	2.6E+01	Aquatic Habitat Goal	5.0E+04	4.7E+02		2.6E+01
PYRENE	2.0E+00	Aquatic Habitat Goal	6.8E+01	1.8E+02	1.4E+02	2.0E+00
SELENIUM	5.0E+00	Aquatic Habitat Goal	5.0E+04	5.0E+01		5.0E+00
SILVER	1.0E+00	Aquatic Habitat Goal	1.0E+02	1.8E+02		1.0E+00
SIMAZINE	2.0E+00	Aquatic Habitat Goal	3.1E+03	4.0E+00		2.0E+00
STYRENE	1.0E+01	Gross Contamination	1.0E+01	1.0E+02	3.1E+05	1.0E+02
TERBACIL	4.7E+02	Drinking Water Toxicity	5.0E+04	4.7E+02		2.3E+03
tert-BUTYL ALCOHOL	4.5E+00	Drinking Water Toxicity	5.0E+04	4.5E+00	(Use soil gas)	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	5.2E-01	Drinking Water Toxicity	5.0E+04	5.2E-01	(Use soil gas)	3.1E+02
TETRACHLOROETHANE, 1,1,2,2-	6.7E-02	Drinking Water Toxicity	5.0E+02	6.7E-02	1.6E+02	4.2E+02
TETRACHLOROETHYLENE	5.0E+00	Drinking Water Toxicity	1.7E+02	5.0E+00	1.4E+02	1.2E+02
TETRACHLOROPHENOL, 2,3,4,6-	1.2E+00	Aquatic Habitat Goal	1.2E+04	1.1E+03		1.2E+00
TETRANITRO-1,3,5,7-TETRAAZOCYCLOOCTANE (HMX)	3.3E+02	Aquatic Habitat Goal	5.0E+04	1.8E+03		3.3E+02
THALLIUM	2.0E+00	Drinking Water Toxicity	5.0E+04	2.0E+00		2.0E+01
TOLUENE	4.0E+01	Gross Contamination	4.0E+01	1.0E+03	5.3E+05	1.3E+02
TOXAPHENE	2.0E-04	Aquatic Habitat Goal	1.4E+02	3.0E+00		2.0E-04
TPH (gasolines)	1.0E+02	Gross Contamination	1.0E+02	1.0E+02	(Use soil gas)	5.0E+02
TPH (middle distillates)	1.0E+02	Gross Contamination	1.0E+02	2.1E+02	(Use soil gas)	6.4E+02
TPH (residual fuels)	1.0E+02	Gross Contamination	1.0E+02	3.7E+02		6.4E+02

TABLE D-1a. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS located within 150 meters of release site)
(ug/l)

CONTAMINANT	[1] Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
TRICHLOROBENZENE, 1,2,4-	2.5E+01	Aquatic Habitat Goal	3.0E+03	7.0E+01	2.0E+03	2.5E+01
TRICHLOROETHANE, 1,1,1-	6.2E+01	Aquatic Habitat Goal	9.7E+02	2.0E+02	2.7E+05	6.2E+01
TRICHLOROETHANE, 1,1,2-	5.0E+00	Drinking Water Toxicity	5.0E+04	5.0E+00	3.0E+02	4.7E+03
TRICHLOROETHYLENE	5.0E+00	Drinking Water Toxicity	3.1E+02	5.0E+00	4.8E+02	3.6E+02
TRICHLOROPHENOL, 2,4,5-	1.1E+01	Aquatic Habitat Goal	2.0E+02	6.1E+02		1.1E+01
TRICHLOROPHENOL, 2,4,6-	6.1E+00	Drinking Water Toxicity	1.0E+02	6.1E+00		4.9E+02
TRICHLOROPHENOXYACETIC ACID, 2,4,5- (2,4,5-T)	3.7E+02	Drinking Water Toxicity	5.0E+04	3.7E+02		6.9E+02
TRICHLOROPHENOXYPROPIONIC ACID, 2,4,5- (2,4,5-TP)	3.0E+01	Aquatic Habitat Goal	5.0E+04	5.0E+01		3.0E+01
TRICHLOROPROPANE, 1,2,3-	6.0E-01	Drinking Water Toxicity	5.0E+04	6.0E-01	(Use soil gas)	1.4E+01
TRICHLOROPROPENE, 1,2,3-	6.1E+01	Drinking Water Toxicity	5.0E+04	6.1E+01	(Use soil gas)	1.5E+02
TRIFLURALIN	8.7E+00	Drinking Water Toxicity	9.2E+01	8.7E+00		2.0E+01
TRINITROBENZENE, 1,3,5-	3.0E+01	Aquatic Habitat Goal	5.0E+04	1.1E+03		3.0E+01
TRINITROPHENYLMETHYLNITRAMINE, 2,4,6- (TETRYL)	1.5E+02	Aquatic Habitat Goal	3.7E+04	1.5E+02		1.5E+02
TRINITROTOLUENE, 2,4,6- (TNT)	2.2E+00	Drinking Water Toxicity	5.0E+04	2.2E+00		1.3E+02
VANADIUM	1.9E+01	Aquatic Habitat Goal	5.0E+04	2.6E+02		1.9E+01
VINYL CHLORIDE	2.0E+00	Drinking Water Toxicity	3.4E+03	2.0E+00	2.1E+01	7.8E+02
XYLENES	2.0E+01	Gross Contamination	2.0E+01	1.0E+04	1.6E+05	1.0E+02
ZINC	2.2E+01	Aquatic Habitat Goal	5.0E+03	1.1E+04		2.2E+01

Notes:
1. Lowest of action levels for gross contamination, drinking water toxicity, vapor intrusion and aquatic habitat impacts. Used to develop soil leaching action levels for protection of groundwater quality.

TPH -Total Petroleum Hydrocarbons. See text for discussion of different TPH categories.
Gross Contamination: Odor threshold, 1/2 solubility or 50000 ug/L maximum, whichever is lower. Intended to limit general groundwater resource degradation.
Drinking Water Toxicity: Based on primary maximum concentration levels (MCLs), or equivalent. Considered protective of human health.
Vapor Intrusion: Addresses potential emission of volatile chemicals from groundwater into buildings and subsequent impact on indoor air. Assumes moderately permeable, sandy soil or fill material immediately beneath building slab and unrestricted ("residential") land use (refer to Chapter 2).
Aquatic Habitat Impacts: Addresses potential discharge of groundwater to estuarine aquatic habitat and subsequent impact on aquatic life; dilution of groundwater upon discharge to surface water not considered, in order to take into account potential impacts to benthic organisms (see Chapter 2).
Review of aquatic ecotoxicty data for ethanol underway. Based on preliminary review of available data, chronic toxicity screening levels likely to be significantly greater than ceiling level of 50,000 ug/L (refer to USEPA 2003b, ECOTOX database).
Method reporting limits and background concentrations replace final screening level as appropriate.

TABLE D-1b. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
ACENAPHTHENE	2.0E+01	Gross Contamination	2.0E+01	3.7E+02	3.9E+03	3.2E+02
ACENAPHTHYLENE	2.4E+02	Drinking Water Toxicity	2.0E+03	2.4E+02	(Use soil gas)	3.0E+02
ACETONE	1.5E+03	Aquatic Habitat Goal	2.0E+04	2.2E+04	4.4E+08	1.5E+03
ALDRIN	4.0E-03	Drinking Water Toxicity	8.5E+00	4.0E-03		1.3E+00
AMETRYN	1.5E+02	Aquatic Habitat Goal	5.0E+04	3.3E+02		1.5E+02
AMINO,2- DINITROTOLUENE,4,6-	7.3E+01	Drinking Water Toxicity	5.0E+04	7.3E+01		1.5E+02
AMINO,4- DINITROTOLUENE,2,6-	7.3E+01	Drinking Water Toxicity	5.0E+04	7.3E+01		1.5E+02
ANTHRACENE	7.3E-01	Aquatic Habitat Goal	2.2E+01	1.8E+03	4.3E+01	7.3E-01
ANTIMONY	6.0E+00	Drinking Water Toxicity	5.0E+04	6.0E+00		1.5E+03
ARSENIC	1.0E+01	Drinking Water Toxicity	5.0E+04	1.0E+01		6.9E+01
ATRAZINE	3.0E+00	Drinking Water Toxicity	1.7E+04	3.0E+00		3.5E+02
BARIUM	2.0E+03	Aquatic Habitat Goal	5.0E+04	2.0E+03		2.0E+03
BENZENE	5.0E+00	Drinking Water Toxicity	1.7E+02	5.0E+00	1.5E+03	1.7E+03
BENZO(a)ANTHRACENE	2.7E-02	Aquatic Habitat Goal	4.7E+00	9.2E-02		2.7E-02
BENZO(a)PYRENE	1.4E-02	Aquatic Habitat Goal	8.1E-01	2.0E-01		1.4E-02
BENZO(b)FLUORANTHENE	9.2E-02	Aquatic Habitat Goal	7.5E-01	9.2E-02		9.2E-02
BENZO(g,h,i)PERYLENE	1.0E-01	Aquatic Habitat Goal	1.3E-01	1.5E+03		1.0E-01
BENZO(k)FLUORANTHENE	4.0E-01	Gross Contamination	4.0E-01	9.2E-01		8.0E-01
BERYLLIUM	4.0E+00	Drinking Water Toxicity	5.0E+04	4.0E+00		4.3E+01
BIPHENYL, 1,1-	5.0E-01	Gross Contamination	5.0E-01	3.0E+02	(Use soil gas)	1.4E+01
BIS(2-CHLOROETHYL)ETHER	1.2E-02	Drinking Water Toxicity	3.6E+02	1.2E-02	1.1E+02	2.4E+05
BIS(2-CHLOROISOPROPYL)ETHER	3.2E-01	Drinking Water Toxicity	3.2E+02	3.2E-01	(Use soil gas)	2.4E+05
BIS(2-ETHYLHEXYL)PHTHALATE	6.0E+00	Drinking Water Toxicity	1.4E+02	6.0E+00		3.2E+01
BORON	4.1E+01	Drinking Water Toxicity	5.0E+04	4.1E+01		7.3E+03
BROMODICHLOROMETHANE	2.2E-01	Drinking Water Toxicity	5.0E+04	2.2E-01	1.6E+02	1.1E+04
BROMOFORM	1.0E+02	Drinking Water Toxicity	5.1E+02	1.0E+02		1.1E+04
BROMOMETHANE	8.7E+00	Drinking Water Toxicity	5.0E+04	8.7E+00	3.6E+02	1.1E+04
CADMIUM	3.0E+00	Aquatic Habitat Goal	5.0E+04	5.0E+00		3.0E+00
CARBON TETRACHLORIDE	5.0E+00	Drinking Water Toxicity	5.2E+02	5.0E+00	3.1E+01	1.2E+04
CHLORDANE (TECHNICAL)	9.0E-02	Aquatic Habitat Goal	2.5E+00	2.0E+00		9.0E-02
CHLOROANILINE, p-	1.2E+00	Drinking Water Toxicity	5.0E+04	1.2E+00		5.0E+00
CHLOROBENZENE	5.0E+01	Gross Contamination	5.0E+01	1.0E+02	9.6E+03	1.6E+02
CHLOROETHANE	3.9E+00	Aquatic Habitat Goal	1.6E+01	8.6E+03	4.4E+05	3.9E+00
CHLOROFORM	7.0E+01	Drinking Water Toxicity	2.4E+03	7.0E+01	7.4E+01	9.6E+03
CHLOROMETHANE	1.8E+00	Drinking Water Toxicity	5.0E+04	1.8E+00	2.9E+02	1.1E+04
CHLOROPHENOL, 2-	1.8E-01	Gross Contamination	1.8E-01	3.0E+01	5.8E+04	1.4E+03
CHROMIUM (Total)	1.0E+02	Drinking Water Toxicity	5.0E+04	1.0E+02		5.7E+02
CHROMIUM III	5.7E+02	Aquatic Habitat Goal	5.0E+04	5.5E+04		5.7E+02
CHROMIUM VI	2.1E-01	Drinking Water Toxicity	5.0E+04	2.1E-01		1.6E+01
CHRYSENE	3.5E-01	Aquatic Habitat Goal	1.0E+00	9.2E+00		3.5E-01
COBALT	4.2E-02	Drinking Water Toxicity	5.0E+04	4.2E-02		3.0E+00
COPPER	2.9E+00	Aquatic Habitat Goal	1.0E+03	1.3E+03		2.9E+00
CYANIDE (Free)	1.0E+00	Aquatic Habitat Goal	1.7E+02	2.0E+02	(Use soil gas)	1.0E+00
CYCLO-1,3,5-TRIMETHYLENE-2,4,6-TRINITRAMINE (RDX)	6.1E-01	Drinking Water Toxicity	3.0E+04	6.1E-01		1.4E+03
DALAPON	2.0E+02	Drinking Water Toxicity	5.0E+04	2.0E+02		3.0E+03

TABLE D-1b. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
DIBENZO(a,h)ANTHTRACENE	9.2E-03	Drinking Water Toxicity	5.2E-01	9.2E-03		1.0E+00
DIBROMO,1,2- CHLOROPROPANE,3-	4.0E-02	Aquatic Habitat Goal	1.0E+01	4.0E-02	(Use soil gas)	4.0E-02
DIBROMOCHLOROMETHANE	1.6E-01	Drinking Water Toxicity	5.0E+04	1.6E-01	2.7E+02	1.1E+04
DIBROMOETHANE, 1,2-	6.5E-03	Drinking Water Toxicity	5.0E+04	6.5E-03	1.2E+01	1.4E+03
DICHLOROBENZENE, 1,2-	1.0E+01	Gross Contamination	1.0E+01	6.0E+02	6.5E+04	3.7E+02
DICHLOROBENZENE, 1,3-	1.8E+02	Drinking Water Toxicity	5.0E+04	1.8E+02	(Use soil gas)	3.7E+02
DICHLOROBENZENE, 1,4-	5.0E+00	Gross Contamination	5.0E+00	7.5E+01	3.0E+02	3.7E+02
DICHLOROBENZIDINE, 3,3-	1.5E-01	Drinking Water Toxicity	1.6E+03	1.5E-01		2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.8E-01	Drinking Water Toxicity	4.5E+01	2.8E-01		6.0E-01
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	2.0E-01	Drinking Water Toxicity	2.0E+01	2.0E-01		1.1E+00
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.3E-02	Aquatic Habitat Goal	2.8E+00	2.0E-01		1.3E-02
DICHLOROETHANE, 1,1-	2.4E+00	Drinking Water Toxicity	5.0E+04	2.4E+00	7.4E+02	4.7E+01
DICHLOROETHANE, 1,2-	1.5E-01	Drinking Water Toxicity	7.0E+03	1.5E-01	1.2E+02	3.8E+04
DICHLOROETHYLENE, 1,1-	7.0E+00	Drinking Water Toxicity	1.5E+03	7.0E+00	5.1E+03	3.9E+03
DICHLOROETHYLENE, Cis 1,2-	7.0E+01	Drinking Water Toxicity	5.0E+04	7.0E+01	4.3E+03	1.2E+04
DICHLOROETHYLENE, Trans 1,2-	1.0E+02	Drinking Water Toxicity	2.6E+02	1.0E+02	3.9E+03	1.2E+04
DICHLOROPHENOL, 2,4-	3.0E-01	Gross Contamination	3.0E-01	1.1E+02		6.7E+02
DICHLOROPHENOXYACETIC ACID (2,4-D)	7.0E+01	Drinking Water Toxicity	5.0E+04	7.0E+01		2.0E+02
DICHLOROPROPANE, 1,2-	5.0E+00	Drinking Water Toxicity	1.0E+01	5.0E+00	2.1E+02	3.4E+03
DICHLOROPROPENE, 1,3-	4.3E-01	Drinking Water Toxicity	5.0E+04	4.3E-01	4.4E+02	2.6E+02
DIELDRIN	4.2E-03	Drinking Water Toxicity	4.1E+01	4.2E-03		7.1E-01
DIETHYLPHTHALATE	9.4E+02	Aquatic Habitat Goal	5.0E+04	2.9E+04		9.4E+02
DIMETHYLPHENOL, 2,4-	1.2E+02	Drinking Water Toxicity	4.0E+02	1.2E+02	1.2E+06	2.7E+02
DIMETHYLPHTHALATE	9.4E+02	Aquatic Habitat Goal	5.0E+04	2.0E+04		9.4E+02
DINITROBENZENE, 1,3-	3.7E+00	Drinking Water Toxicity	5.0E+04	3.7E+00		1.1E+02
DINITROPHENOL, 2,4-	7.3E+01	Drinking Water Toxicity	5.0E+04	7.3E+01		2.3E+02
DINITROTOLUENE, 2,4- (2,4-DNT)	7.3E+01	Drinking Water Toxicity	5.0E+04	7.3E+01		1.1E+02
DINITROTOLUENE, 2,6- (2,6-DNT)	3.7E+01	Drinking Water Toxicity	5.0E+04	3.7E+01		1.1E+02
DIOXANE, 1,4-	6.1E+00	Drinking Water Toxicity	5.0E+04	6.1E+00		3.4E+06
DIOXINS (TEQ)	3.0E-05	Drinking Water Toxicity	6.0E-02	3.0E-05		3.0E-03
DIURON	7.3E+01	Drinking Water Toxicity	2.1E+04	7.3E+01		2.0E+02
ENDOSULFAN	3.4E-02	Aquatic Habitat Goal	2.3E+02	2.2E+02		3.4E-02
ENDRIN	3.7E-02	Aquatic Habitat Goal	4.1E+01	2.0E+00		3.7E-02
ETHANOL	5.0E+04	Gross Contamination	5.0E+04			
ETHYLBENZENE	3.0E+01	Gross Contamination	3.0E+01	7.0E+02	5.2E+03	4.3E+02
FLUORANTHENE	4.0E+01	Aquatic Habitat Goal	1.3E+02	1.5E+03		4.0E+01
FLUORENE	2.4E+02	Drinking Water Toxicity	9.5E+02	2.4E+02	1.9E+03	3.0E+02
GLYPHOSATE	6.0E+02	Aquatic Habitat Goal	5.0E+04	7.0E+02		6.0E+02
HEPTACHLOR	5.3E-02	Aquatic Habitat Goal	2.0E+01	4.0E-01		5.3E-02
HEPTACHLOR EPOXIDE	5.3E-02	Aquatic Habitat Goal	1.0E+02	2.0E-01		5.3E-02
HEXACHLOROBENZENE	1.0E+00	Drinking Water Toxicity	3.1E+00	1.0E+00		6.0E+00
HEXACHLOROBUTADIENE	8.6E-01	Drinking Water Toxicity	6.0E+00	8.6E-01		1.1E+01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	1.6E-01	Aquatic Habitat Goal	4.0E+03	2.0E-01		1.6E-01
HEXACHLOROETHANE	4.8E+00	Drinking Water Toxicity	1.0E+01	4.8E+00		3.1E+02
HEXAZINONE	1.2E+03	Drinking Water Toxicity	5.0E+04	1.2E+03		5.0E+04

TABLE D-1b. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
INDENO(1,2,3-cd)PYRENE	9.2E-02	Aquatic Habitat Goal	9.5E-02	9.2E-02		9.2E-02
ISOPHORONE	7.1E+01	Drinking Water Toxicity	5.0E+04	7.1E+01		4.3E+03
LEAD	1.5E+01	Drinking Water Toxicity	5.0E+04	1.5E+01		2.9E+01
MERCURY	2.0E+00	Drinking Water Toxicity	3.0E+01	2.0E+00	(Use soil gas)	2.1E+00
METHOXYCHLOR	3.0E-02	Aquatic Habitat Goal	5.0E+01	4.0E+01		3.0E-02
METHYL ETHYL KETONE	7.1E+03	Drinking Water Toxicity	8.4E+03	7.1E+03	1.5E+08	1.4E+04
METHYL ISOBUTYL KETONE	1.7E+02	Aquatic Habitat Goal	1.3E+03	2.0E+03	1.9E+07	1.7E+02
METHYL MERCURY	3.0E-03	Aquatic Habitat Goal	5.0E+04	3.7E+00		3.0E-03
METHYL TERT BUTYL ETHER	5.0E+00	Gross Contamination	5.0E+00	1.2E+01	2.1E+04	5.3E+04
METHYLENE CHLORIDE	4.8E+00	Drinking Water Toxicity	9.1E+03	4.8E+00	3.1E+03	1.1E+04
METHYLNAPHTHALENE, 1-	4.7E+00	Drinking Water Toxicity	1.0E+01	4.7E+00	1.1E+04	3.0E+02
METHYLNAPHTHALENE, 2-	1.0E+01	Gross Contamination	1.0E+01	2.4E+01	2.5E+04	3.0E+02
MOLYBDENUM	1.8E+02	Drinking Water Toxicity	5.0E+04	1.8E+02		2.4E+02
NAPHTHALENE	1.7E+01	Drinking Water Toxicity	2.1E+01	1.7E+01	2.5E+03	7.7E+02
NICKEL	5.0E+00	Aquatic Habitat Goal	5.0E+04	1.0E+02		5.0E+00
NITROBENZENE	3.4E+00	Drinking Water Toxicity	5.0E+04	3.4E+00	(Use soil gas)	2.0E+03
NITROGLYCERIN	3.7E+00	Drinking Water Toxicity	5.0E+04	3.7E+00		1.4E+02
NITROTOLUENE, 2-	6.2E-02	Drinking Water Toxicity	5.0E+04	6.2E-02	(Use soil gas)	7.5E+03
NITROTOLUENE, 3-	1.2E+02	Drinking Water Toxicity	5.0E+04	1.2E+02	(Use soil gas)	3.8E+03
NITROTOLUENE, 4-	4.2E+00	Drinking Water Toxicity	5.0E+04	4.2E+00		3.3E+03
PENTACHLOROPHENOL	1.0E+00	Drinking Water Toxicity	3.0E+01	1.0E+00		1.3E+01
PENTAERYTHRITOLTETRANITRATE (PETN)	6.1E-01	Drinking Water Toxicity	2.2E+04	6.1E-01		4.3E+04
PERCHLORATE	2.6E+01	Drinking Water Toxicity	5.0E+04	2.6E+01		6.0E+02
PHENANTHRENE	7.7E+00	Aquatic Habitat Goal	4.1E+02	2.4E+02	(Use soil gas)	7.7E+00
PHENOL	5.0E+00	Gross Contamination	5.0E+00	4.0E+02		3.4E+03
POLYCHLORINATED BIPHENYLS (PCBs)	5.0E-01	Drinking Water Toxicity	1.6E+01	5.0E-01		2.0E+00
PROPICONAZOLE	2.6E+02	Aquatic Habitat Goal	5.0E+04	4.7E+02		2.6E+02
PYRENE	2.0E+00	Aquatic Habitat Goal	6.8E+01	1.8E+02	1.4E+02	2.0E+00
SELENIUM	2.0E+01	Aquatic Habitat Goal	5.0E+04	5.0E+01		2.0E+01
SILVER	1.0E+00	Aquatic Habitat Goal	1.0E+02	1.8E+02		1.0E+00
SIMAZINE	4.0E+00	Drinking Water Toxicity	3.1E+03	4.0E+00		1.0E+01
STYRENE	1.0E+01	Gross Contamination	1.0E+01	1.0E+02	3.1E+05	1.0E+02
TERBACIL	4.7E+02	Drinking Water Toxicity	5.0E+04	4.7E+02		2.3E+04
tert-BUTYL ALCOHOL	4.5E+00	Drinking Water Toxicity	5.0E+04	4.5E+00	(Use soil gas)	1.8E+05
TETRACHLOROETHANE, 1,1,1,2-	5.2E-01	Drinking Water Toxicity	5.0E+04	5.2E-01	(Use soil gas)	3.1E+03
TETRACHLOROETHANE, 1,1,2,2-	6.7E-02	Drinking Water Toxicity	5.0E+02	6.7E-02	1.6E+02	3.0E+03
TETRACHLOROETHYLENE	5.0E+00	Drinking Water Toxicity	1.7E+02	5.0E+00	1.4E+02	1.8E+03
TETRACHLOROPHENOL, 2,3,4,6-	1.0E+01	Aquatic Habitat Goal	1.2E+04	1.1E+03		1.0E+01
TETRANITRO-1,3,5,7-TETRAAZOCYCLOOCTANE (HMX)	1.8E+03	Drinking Water Toxicity	5.0E+04	1.8E+03		1.9E+03
THALLIUM	2.0E+00	Drinking Water Toxicity	5.0E+04	2.0E+00		4.7E+02
TOLUENE	4.0E+01	Gross Contamination	4.0E+01	1.0E+03	5.3E+05	5.8E+03
TOXAPHENE	2.1E-01	Aquatic Habitat Goal	1.4E+02	3.0E+00		2.1E-01
TPH (gasolines)	1.0E+02	Gross Contamination	1.0E+02	1.0E+02	(Use soil gas)	5.0E+03
TPH (middle distillates)	1.0E+02	Gross Contamination	1.0E+02	2.1E+02	(Use soil gas)	2.5E+03
TPH (residual fuels)	1.0E+02	Gross Contamination	1.0E+02	3.7E+02		2.5E+03

TABLE D-1b. GROUNDWATER ACTION LEVELS
(Groundwater IS a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Taste & Odors, etc.) Table G-1	Drinking Water Toxicity Table D-3a	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
TRICHLOROBENZENE, 1,2,4-	7.0E+01	Drinking Water Toxicity	3.0E+03	7.0E+01	2.0E+03	1.6E+02
TRICHLOROETHANE, 1,1,1-	2.0E+02	Drinking Water Toxicity	9.7E+02	2.0E+02	2.7E+05	6.0E+03
TRICHLOROETHANE, 1,1,2-	5.0E+00	Drinking Water Toxicity	5.0E+04	5.0E+00	3.0E+02	6.0E+03
TRICHLOROETHYLENE	5.0E+00	Drinking Water Toxicity	3.1E+02	5.0E+00	4.8E+02	7.0E+02
TRICHLOROPHENOL, 2,4,5-	1.0E+02	Aquatic Habitat Goal	2.0E+02	6.1E+02		1.0E+02
TRICHLOROPHENOL, 2,4,6-	6.1E+00	Drinking Water Toxicity	1.0E+02	6.1E+00		4.9E+02
TRICHLOROPHENOXYACETIC ACID, 2,4,5- (2,4,5-T)	3.7E+02	Drinking Water Toxicity	5.0E+04	3.7E+02		6.9E+02
TRICHLOROPHENOXYPROPIONIC ACID, 2,4,5- (2,4,5-TP)	3.0E+01	Aquatic Habitat Goal	5.0E+04	5.0E+01		3.0E+01
TRICHLOROPROPANE, 1,2,3-	6.0E-01	Drinking Water Toxicity	5.0E+04	6.0E-01	(Use soil gas)	1.4E+02
TRICHLOROPROPENE, 1,2,3-	2.2E+00	Aquatic Habitat Goal	5.0E+04	6.1E+01	(Use soil gas)	2.2E+00
TRIFLURALIN	8.7E+00	Drinking Water Toxicity	9.2E+01	8.7E+00		2.0E+01
TRINITROBENZENE, 1,3,5-	1.4E+02	Aquatic Habitat Goal	5.0E+04	1.1E+03		1.4E+02
TRINITROPHENYLMETHYLNITRAMINE, 2,4,6- (TETRYL)	1.5E+02	Aquatic Habitat Goal	3.7E+04	1.5E+02		1.5E+02
TRINITROTOLUENE, 2,4,6- (TNT)	2.2E+00	Drinking Water Toxicity	5.0E+04	2.2E+00		5.7E+02
VANADIUM	1.9E+01	Aquatic Habitat Goal	5.0E+04	2.6E+02		1.9E+01
VINYL CHLORIDE	2.0E+00	Drinking Water Toxicity	3.4E+03	2.0E+00	2.1E+01	7.8E+02
XYLENES	2.0E+01	Gross Contamination	2.0E+01	1.0E+04	1.6E+05	1.0E+03
ZINC	2.2E+01	Aquatic Habitat Goal	5.0E+03	1.1E+04		2.2E+01

Notes:

1. Lowest of action levels for gross contamination, drinking water toxicity, vapor intrusion and aquatic habitat impacts. Used to develop soil leaching action levels for protection of groundwater quality.

TPH -Total Petroleum Hydrocarbons. See text for discussion of different TPH categories.
Gross Contamination: Odor threshold, 1/2 solubility or 50000 ug/L maximum, whichever is lower. Intended to limit general groundwater resource degradation.
Drinking Water Toxicity: Based on primary maximum concentration levels (MCLs), or equivalent. Considered protective of human health.
Vapor Intrusion: Addresses potential emission of volatile chemicals from groundwater into buildings and subsequent impact on indoor air. Assumes moderately permeable, sandy soil or fill material immediately beneath building slab and unrestricted ("residential") land use (refer to Chapter 2).
Aquatic Habitat Impacts: Addresses potential discharge of groundwater to estuarine aquatic habitat and subsequent impact on aquatic life; dilution of groundwater upon discharge to surface water not considered, in order to take into account potential impacts to benthic organisms (see Chapter 2).
Review of aquatic ecotoxicty data for ethanol underway. Based on preliminary review of available data, chronic toxicity screening levels likely to be significantly greater than ceiling level of 50,000 ug/L (refer to USEPA 2003b, ECOTOX database).
Method reporting limits and background concentrations replace final screening level as appropriate.

TABLE D-1c. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
ACENAPHTHENE	2.3E+01	Aquatic Habitat Goal	2.0E+02	3.9E+03	2.3E+01
ACENAPHTHYLENE	3.0E+01	Aquatic Habitat Goal	2.0E+03	(Use soil gas)	3.0E+01
ACETONE	1.5E+03	Aquatic Habitat Goal	5.0E+04	4.4E+08	1.5E+03
ALDRIN	1.3E-01	Aquatic Habitat Goal	8.5E+00		1.3E-01
AMETRYN	1.5E+01	Aquatic Habitat Goal	5.0E+04		1.5E+01
AMINO,2- DINITROTOLUENE,4,6-	1.5E+01	Aquatic Habitat Goal	5.0E+04		1.5E+01
AMINO,4- DINITROTOLUENE,2,6-	1.5E+01	Aquatic Habitat Goal	5.0E+04		1.5E+01
ANTHRACENE	7.3E-01	Aquatic Habitat Goal	2.2E+01	4.3E+01	7.3E-01
ANTIMONY	3.0E+01	Aquatic Habitat Goal	5.0E+04		3.0E+01
ARSENIC	3.6E+01	Aquatic Habitat Goal	5.0E+04		3.6E+01
ATRAZINE	1.2E+01	Aquatic Habitat Goal	1.7E+04		1.2E+01
BARIUM	2.0E+03	Aquatic Habitat Goal	5.0E+04		2.0E+03
BENZENE	4.6E+01	Aquatic Habitat Goal	2.0E+04	1.5E+03	4.6E+01
BENZO(a)ANTHRACENE	2.7E-02	Aquatic Habitat Goal	4.7E+00		2.7E-02
BENZO(a)PYRENE	1.4E-02	Aquatic Habitat Goal	8.1E-01		1.4E-02
BENZO(b)FLUORANTHENE	9.2E-02	Aquatic Habitat Goal	7.5E-01		9.2E-02
BENZO(g,h,i)PERYLENE	1.0E-01	Aquatic Habitat Goal	1.3E-01		1.0E-01
BENZO(k)FLUORANTHENE	4.0E-01	Gross Contamination	4.0E-01		3.7E+00
BERYLLIUM	2.7E+00	Aquatic Habitat Goal	5.0E+04		2.7E+00
BIPHENYL, 1,1-	5.0E+00	Gross Contamination	5.0E+00	(Use soil gas)	1.4E+01
BIS(2-CHLOROETHYL)ETHER	6.1E+01	Aquatic Habitat Goal	3.6E+03	1.1E+02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.1E+01	Aquatic Habitat Goal	3.2E+03	(Use soil gas)	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	3.2E+01	Aquatic Habitat Goal	1.4E+02		3.2E+01
BORON	7.3E+03	Aquatic Habitat Goal	5.0E+04		7.3E+03
BROMODICHLOROMETHANE	1.6E+02	Vapor Intrusion	5.0E+04	1.6E+02	3.2E+03
BROMOFORM	3.2E+03	Aquatic Habitat Goal	5.1E+03		3.2E+03
BROMOMETHANE	1.6E+02	Aquatic Habitat Goal	5.0E+04	3.6E+02	1.6E+02
CADMIUM	3.0E+00	Aquatic Habitat Goal	5.0E+04		3.0E+00
CARBON TETRACHLORIDE	9.8E+00	Aquatic Habitat Goal	5.2E+03	3.1E+01	9.8E+00
CHLORDANE (TECHNICAL)	4.0E-03	Aquatic Habitat Goal	2.5E+01		4.0E-03
CHLOROANILINE, p-	5.0E+00	Aquatic Habitat Goal	5.0E+04		5.0E+00
CHLOROBENZENE	2.5E+01	Aquatic Habitat Goal	5.0E+02	9.6E+03	2.5E+01
CHLOROETHANE	1.6E+02	Gross Contamination	1.6E+02	4.4E+05	1.2E+04
CHLOROFORM	7.4E+01	Vapor Intrusion	2.4E+04	7.4E+01	6.2E+02
CHLOROMETHANE	2.9E+02	Vapor Intrusion	5.0E+04	2.9E+02	3.2E+03
CHLOROPHENOL, 2-	1.8E+00	Gross Contamination	1.8E+00	5.8E+04	1.4E+02
CHROMIUM (Total)	7.4E+01	Aquatic Habitat Goal	5.0E+04		7.4E+01
CHROMIUM III	7.4E+01	Aquatic Habitat Goal	5.0E+04		7.4E+01
CHROMIUM VI	1.1E+01	Aquatic Habitat Goal	5.0E+04		1.1E+01
CHRYSENE	3.5E-01	Aquatic Habitat Goal	1.0E+00		3.5E-01
COBALT	3.0E+00	Aquatic Habitat Goal	5.0E+04		3.0E+00
COPPER	2.9E+00	Aquatic Habitat Goal	5.0E+04		2.9E+00
CYANIDE (Free)	1.0E+00	Aquatic Habitat Goal	1.7E+03	(Use soil gas)	1.0E+00
CYCLO-1,3,5-TRIMETHYLENE-2,4,6-TRINITRAMINE (RDX)	1.9E+02	Aquatic Habitat Goal	3.0E+04		1.9E+02
DALAPON	3.0E+02	Aquatic Habitat Goal	5.0E+04		3.0E+02

TABLE D-1c. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS located within 150m of release site)
(ug/l)

CONTAINMENT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
DIBENZO(a,h)ANTHTRACENE	5.2E-01	Gross Contamination	5.2E-01		7.5E+00
DIBROMO,1,2- CHLOROPROPANE,3-	4.0E-02	Aquatic Habitat Goal	1.0E+02	(Use soil gas)	4.0E-02
DIBROMOCHLOROMETHANE	2.7E+02	Vapor Intrusion	5.0E+04	2.7E+02	3.2E+03
DIBROMOETHANE, 1,2-	1.2E+01	Vapor Intrusion	5.0E+04	1.2E+01	1.4E+03
DICHLOROBENZENE, 1,2-	1.4E+01	Aquatic Habitat Goal	1.0E+02	6.5E+04	1.4E+01
DICHLOROBENZENE, 1,3-	6.5E+01	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	6.5E+01
DICHLOROBENZENE, 1,4-	1.5E+01	Aquatic Habitat Goal	1.1E+02	3.0E+02	1.5E+01
DICHLOROBENZIDINE, 3,3-	2.5E+02	Aquatic Habitat Goal	1.6E+03		2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	1.0E-03	Aquatic Habitat Goal	4.5E+01		1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.0E-03	Aquatic Habitat Goal	2.0E+01		1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.0E-03	Aquatic Habitat Goal	2.8E+00		1.0E-03
DICHLOROETHANE, 1,1-	4.7E+01	Aquatic Habitat Goal	5.0E+04	7.4E+02	4.7E+01
DICHLOROETHANE, 1,2-	1.2E+02	Vapor Intrusion	5.0E+04	1.2E+02	1.0E+04
DICHLOROETHYLENE, 1,1-	2.5E+01	Aquatic Habitat Goal	1.5E+04	5.1E+03	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	5.9E+02	Aquatic Habitat Goal	5.0E+04	4.3E+03	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	5.9E+02	Aquatic Habitat Goal	2.6E+03	3.9E+03	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	Gross Contamination	3.0E+00		1.8E+02
DICHLOROPHENOXYACETIC ACID (2,4-D)	4.0E+01	Aquatic Habitat Goal	5.0E+04		4.0E+01
DICHLOROPROPANE, 1,2-	1.0E+02	Gross Contamination	1.0E+02	2.1E+02	1.5E+03
DICHLOROPROPENE, 1,3-	1.2E+02	Aquatic Habitat Goal	5.0E+04	4.4E+02	1.2E+02
DIELDRIN	1.9E-03	Aquatic Habitat Goal	1.3E+02		1.9E-03
DIETHYLPHTHALATE	1.5E+00	Aquatic Habitat Goal	5.0E+04		1.5E+00
DIMETHYLPHENOL, 2,4-	1.1E+02	Aquatic Habitat Goal	4.0E+03	1.2E+06	1.1E+02
DIMETHYLPHTHALATE	1.5E+00	Aquatic Habitat Goal	5.0E+04		1.5E+00
DINITROBENZENE, 1,3-	3.0E+01	Aquatic Habitat Goal	5.0E+04		3.0E+01
DINITROPHENOL, 2,4-	7.5E+01	Aquatic Habitat Goal	5.0E+04		7.5E+01
DINITROTOLUENE, 2,4- (2,4-DNT)	4.4E+01	Aquatic Habitat Goal	5.0E+04		4.4E+01
DINITROTOLUENE, 2,6- (2,6-DNT)	4.4E+01	Aquatic Habitat Goal	5.0E+04		4.4E+01
DIOXANE, 1,4-	5.0E+04	Gross Contamination	5.0E+04		3.4E+05
DIOXINS (TEQ)	5.0E-06	Aquatic Habitat Goal	6.0E-02		5.0E-06
DIURON	6.0E+01	Aquatic Habitat Goal	2.1E+04		6.0E+01
ENDOSULFAN	8.7E-03	Aquatic Habitat Goal	2.3E+02		8.7E-03
ENDRIN	2.3E-03	Aquatic Habitat Goal	1.3E+02		2.3E-03
ETHANOL	5.0E+04	Gross Contamination	5.0E+04		
ETHYLBENZENE	2.9E+02	Aquatic Habitat Goal	3.0E+02	5.2E+03	2.9E+02
FLUORANTHENE	8.0E+00	Aquatic Habitat Goal	1.3E+02		8.0E+00
FLUORENE	3.9E+00	Aquatic Habitat Goal	9.5E+02	1.9E+03	3.9E+00
GLYPHOSATE	6.5E+01	Aquatic Habitat Goal	5.0E+04		6.5E+01
HEPTACHLOR	3.6E-03	Aquatic Habitat Goal	9.0E+01		3.6E-03
HEPTACHLOR EPOXIDE	3.6E-03	Aquatic Habitat Goal	1.0E+02		3.6E-03
HEXACHLOROBENZENE	3.1E+00	Gross Contamination	3.1E+00		3.7E+00
HEXACHLOROBUTADIENE	4.7E+00	Aquatic Habitat Goal	6.0E+01		4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	8.0E-02	Aquatic Habitat Goal	4.0E+03		8.0E-02
HEXACHLOROETHANE	1.2E+01	Aquatic Habitat Goal	1.0E+02		1.2E+01
HEXAZINONE	5.0E+03	Aquatic Habitat Goal	5.0E+04		5.0E+03

TABLE D-1c. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS located within 150m of release site)
(ug/l)

CONTAINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
INDENO(1,2,3-cd)PYRENE	9.2E-02	Aquatic Habitat Goal	9.5E-02		9.2E-02
ISOPHORONE	1.3E+02	Aquatic Habitat Goal	5.0E+04		1.3E+02
LEAD	5.6E+00	Aquatic Habitat Goal	5.0E+04		5.6E+00
MERCURY	2.5E-02	Aquatic Habitat Goal	3.0E+01	(Use soil gas)	2.5E-02
METHOXYCHLOR	3.0E-02	Aquatic Habitat Goal	5.0E+01		3.0E-02
METHYL ETHYL KETONE	1.4E+04	Aquatic Habitat Goal	5.0E+04	1.5E+08	1.4E+04
METHYL ISOBUTYL KETONE	1.7E+02	Aquatic Habitat Goal	1.3E+04	1.9E+07	1.7E+02
METHYL MERCURY	3.0E-03	Aquatic Habitat Goal	5.0E+04		3.0E-03
METHYL TERT BUTYL ETHER	1.8E+03	Gross Contamination	1.8E+03	2.1E+04	1.8E+04
METHYLENE CHLORIDE	2.2E+03	Aquatic Habitat Goal	5.0E+04	3.1E+03	2.2E+03
METHYLNAPHTHALENE, 1-	2.1E+00	Aquatic Habitat Goal	1.0E+02	1.1E+04	2.1E+00
METHYLNAPHTHALENE, 2-	2.1E+00	Aquatic Habitat Goal	1.0E+02	2.5E+04	2.1E+00
MOLYBDENUM	2.4E+02	Aquatic Habitat Goal	5.0E+04		2.4E+02
NAPHTHALENE	2.4E+01	Aquatic Habitat Goal	2.1E+02	2.5E+03	2.4E+01
NICKEL	5.0E+00	Aquatic Habitat Goal	5.0E+04		5.0E+00
NITROBENZENE	6.0E+01	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	6.0E+01
NITROGLYCERIN	1.4E+02	Aquatic Habitat Goal	5.0E+04		1.4E+02
NITROTOLUENE, 2-	1.0E+03	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	1.0E+03
NITROTOLUENE, 3-	3.8E+02	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	3.8E+02
NITROTOLUENE, 4-	1.6E+03	Aquatic Habitat Goal	5.0E+04		1.6E+03
PENTACHLOROPHENOL	7.9E+00	Aquatic Habitat Goal	5.9E+03		7.9E+00
PENTAERYTHRITOLTETRANITRATE (PETN)	2.2E+04	Gross Contamination	2.2E+04		8.5E+04
PERCHLORATE	6.0E+02	Aquatic Habitat Goal	5.0E+04		6.0E+02
PHENANTHRENE	4.6E+00	Aquatic Habitat Goal	4.1E+02	(Use soil gas)	4.6E+00
PHENOL	1.3E+03	Aquatic Habitat Goal	5.0E+04		1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	1.4E-02	Aquatic Habitat Goal	1.6E+01		1.4E-02
PROPICONAZOLE	2.6E+01	Aquatic Habitat Goal	5.0E+04		2.6E+01
PYRENE	2.0E+00	Aquatic Habitat Goal	6.8E+01	1.4E+02	2.0E+00
SELENIUM	5.0E+00	Aquatic Habitat Goal	5.0E+04		5.0E+00
SILVER	1.0E+00	Aquatic Habitat Goal	5.0E+04		1.0E+00
SIMAZINE	2.0E+00	Aquatic Habitat Goal	3.1E+03		2.0E+00
STYRENE	1.0E+02	Aquatic Habitat Goal	1.1E+02	3.1E+05	1.0E+02
TERBACIL	2.3E+03	Aquatic Habitat Goal	5.0E+04		2.3E+03
tert-BUTYL ALCOHOL	1.8E+04	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	3.1E+02	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	3.1E+02
TETRACHLOROETHANE, 1,1,2,2-	1.6E+02	Vapor Intrusion	5.0E+03	1.6E+02	4.2E+02
TETRACHLOROETHYLENE	1.2E+02	Aquatic Habitat Goal	3.0E+03	1.4E+02	1.2E+02
TETRACHLOROPHENOL, 2,3,4,6-	1.2E+00	Aquatic Habitat Goal	1.2E+04		1.2E+00
TETRANITRO-1,3,5,7-TETRAAZOCYCLOOCTANE (HMX)	3.3E+02	Aquatic Habitat Goal	5.0E+04		3.3E+02
THALLIUM	2.0E+01	Aquatic Habitat Goal	5.0E+04		2.0E+01
TOLUENE	1.3E+02	Aquatic Habitat Goal	4.0E+02	5.3E+05	1.3E+02
TOXAPHENE	2.0E-04	Aquatic Habitat Goal	1.4E+02		2.0E-04
TPH (gasolines)	5.0E+02	Aquatic Habitat Goal	5.0E+03	(Use soil gas)	5.0E+02
TPH (middle distillates)	6.4E+02	Aquatic Habitat Goal	2.5E+03	(Use soil gas)	6.4E+02
TPH (residual fuels)	6.4E+02	Aquatic Habitat Goal	2.5E+03		6.4E+02

TABLE D-1c. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS located within 150m of release site)
(ug/l)

CONTAINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (chronic) Table D-4a
TRICHLOROBENZENE, 1,2,4-	2.5E+01	Aquatic Habitat Goal	2.5E+04	2.0E+03	2.5E+01
TRICHLOROETHANE, 1,1,1-	6.2E+01	Aquatic Habitat Goal	5.0E+04	2.7E+05	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.0E+02	Vapor Intrusion	5.0E+04	3.0E+02	4.7E+03
TRICHLOROETHYLENE	3.6E+02	Aquatic Habitat Goal	5.0E+04	4.8E+02	3.6E+02
TRICHLOROPHENOL, 2,4,5-	1.1E+01	Aquatic Habitat Goal	2.0E+03		1.1E+01
TRICHLOROPHENOL, 2,4,6-	4.9E+02	Aquatic Habitat Goal	1.0E+03		4.9E+02
TRICHLOROPHENOXYACETIC ACID, 2,4,5- (2,4,5-T)	6.9E+02	Aquatic Habitat Goal	5.0E+04		6.9E+02
TRICHLOROPHENOXYPROPIONIC ACID, 2,4,5- (2,4,5-TP)	3.0E+01	Aquatic Habitat Goal	5.0E+04		3.0E+01
TRICHLOROPROPANE, 1,2,3-	1.4E+01	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	1.4E+01
TRICHLOROPROPENE, 1,2,3-	1.5E+02	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	1.5E+02
TRIFLURALIN	2.0E+01	Aquatic Habitat Goal	9.2E+01		2.0E+01
TRINITROBENZENE, 1,3,5-	3.0E+01	Aquatic Habitat Goal	5.0E+04		3.0E+01
TRINITROPHENYLMETHYLNITRAMINE, 2,4,6- (TETRYL)	1.5E+02	Aquatic Habitat Goal	3.7E+04		1.5E+02
TRINITROTOLUENE, 2,4,6- (TNT)	1.3E+02	Aquatic Habitat Goal	5.0E+04		1.3E+02
VANADIUM	1.9E+01	Aquatic Habitat Goal	5.0E+04		1.9E+01
VINYL CHLORIDE	2.1E+01	Vapor Intrusion	3.4E+04	2.1E+01	7.8E+02
XYLENES	1.0E+02	Aquatic Habitat Goal	5.3E+03	1.6E+05	1.0E+02
ZINC	2.2E+01	Aquatic Habitat Goal	5.0E+04		2.2E+01

Notes:
1. Lowest of action levels for gross contamination, vapor intrusion and aquatic habitat impacts. Used to develop soil leaching action levels for protection of groundwater quality.

TPH -Total Petroleum Hydrocarbons. See text for discussion of different TPH categories.
Gross Contamination: Odor threshold, 1/2 solubility or 50000 ug/L maximum, whichever is lower. Intended to limit general groundwater resource degradation.
Vapor Intrusion: Addresses potential emission of volatile chemicals from groundwater into buildings and subsequent impact on indoor air. Assumes moderately permeable, sandy soil or fill material immediately beneath building slab and unrestricted ("residential") land use (refer to Chapter 2).
Aquatic Habitat Impacts: Addresses potential discharge of groundwater to estuarine aquatic habitat and subsequent impact on aquatic life; dilution of groundwater upon discharge to surface water not considered, in order to take into account potential impacts to benthic organisms (see Chapter 2).
Review of aquatic ecotoxicty data for ethanol underway. Based on preliminary review of available data, chronic toxicity screening levels likely to be significantly greater than ceiling level of 50,000 ug/L (refer to USEPA 2003b, ECOTOX database).
Method reporting limits and background concentrations replace final screening level as appropriate.
Method detection limits and background concentrations replace final screening level as appropriate.

TABLE D-1d. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
ACENAPHTHENE	2.0E+02	Gross Contamination	2.0E+02	3.9E+03	3.2E+02
ACENAPHTHYLENE	3.0E+02	Aquatic Habitat Goal	2.0E+03	(Use soil gas)	3.0E+02
ACETONE	1.5E+03	Aquatic Habitat Goal	5.0E+04	4.4E+08	1.5E+03
ALDRIN	1.3E+00	Aquatic Habitat Goal	8.5E+00		1.3E+00
AMETRYN	1.5E+02	Aquatic Habitat Goal	5.0E+04		1.5E+02
AMINO,2- DINITROTOLUENE,4,6-	1.5E+02	Aquatic Habitat Goal	5.0E+04		1.5E+02
AMINO,4- DINITROTOLUENE,2,6-	1.5E+02	Aquatic Habitat Goal	5.0E+04		1.5E+02
ANTHRACENE	7.3E-01	Aquatic Habitat Goal	2.2E+01	4.3E+01	7.3E-01
ANTIMONY	1.5E+03	Aquatic Habitat Goal	5.0E+04		1.5E+03
ARSENIC	6.9E+01	Aquatic Habitat Goal	5.0E+04		6.9E+01
ATRAZINE	3.5E+02	Aquatic Habitat Goal	1.7E+04		3.5E+02
BARIUM	2.0E+03	Aquatic Habitat Goal	5.0E+04		2.0E+03
BENZENE	1.5E+03	Vapor Intrusion	2.0E+04	1.5E+03	1.7E+03
BENZO(a)ANTHRACENE	2.7E-02	Aquatic Habitat Goal	4.7E+00		2.7E-02
BENZO(a)PYRENE	1.4E-02	Aquatic Habitat Goal	8.1E-01		1.4E-02
BENZO(b)FLUORANTHENE	9.2E-02	Aquatic Habitat Goal	7.5E-01		9.2E-02
BENZO(g,h,i)PERYLENE	1.0E-01	Aquatic Habitat Goal	1.3E-01		1.0E-01
BENZO(k)FLUORANTHENE	4.0E-01	Gross Contamination	4.0E-01		8.0E-01
BERYLLIUM	4.3E+01	Aquatic Habitat Goal	5.0E+04		4.3E+01
BIPHENYL, 1,1-	5.0E+00	Gross Contamination	5.0E+00	(Use soil gas)	1.4E+01
BIS(2-CHLOROETHYL)ETHER	1.1E+02	Vapor Intrusion	3.6E+03	1.1E+02	2.4E+05
BIS(2-CHLOROISOPROPYL)ETHER	3.2E+03	Gross Contamination	3.2E+03	(Use soil gas)	2.4E+05
BIS(2-ETHYLHEXYL)PHTHALATE	3.2E+01	Aquatic Habitat Goal	1.4E+02		3.2E+01
BORON	7.3E+03	Aquatic Habitat Goal	5.0E+04		7.3E+03
BROMODICHLOROMETHANE	1.6E+02	Vapor Intrusion	5.0E+04	1.6E+02	1.1E+04
BROMOFORM	5.1E+03	Gross Contamination	5.1E+03		1.1E+04
BROMOMETHANE	3.6E+02	Vapor Intrusion	5.0E+04	3.6E+02	1.1E+04
CADMIUM	3.0E+00	Aquatic Habitat Goal	5.0E+04		3.0E+00
CARBON TETRACHLORIDE	3.1E+01	Vapor Intrusion	5.2E+03	3.1E+01	1.2E+04
CHLORDANE (TECHNICAL)	9.0E-02	Aquatic Habitat Goal	2.5E+01		9.0E-02
CHLOROANILINE, p-	5.0E+00	Aquatic Habitat Goal	5.0E+04		5.0E+00
CHLOROBENZENE	1.6E+02	Aquatic Habitat Goal	5.0E+02	9.6E+03	1.6E+02
CHLOROETHANE	3.9E+00	Aquatic Habitat Goal	1.6E+02	4.4E+05	3.9E+00
CHLOROFORM	7.4E+01	Vapor Intrusion	2.4E+04	7.4E+01	9.6E+03
CHLOROMETHANE	2.9E+02	Vapor Intrusion	5.0E+04	2.9E+02	1.1E+04
CHLOROPHENOL, 2-	1.8E+00	Gross Contamination	1.8E+00	5.8E+04	1.4E+03
CHROMIUM (Total)	5.7E+02	Aquatic Habitat Goal	5.0E+04		5.7E+02
CHROMIUM III	5.7E+02	Aquatic Habitat Goal	5.0E+04		5.7E+02
CHROMIUM VI	1.6E+01	Aquatic Habitat Goal	5.0E+04		1.6E+01
CHRYSENE	3.5E-01	Aquatic Habitat Goal	1.0E+00		3.5E-01
COBALT	3.0E+00	Aquatic Habitat Goal	5.0E+04		3.0E+00
COPPER	2.9E+00	Aquatic Habitat Goal	5.0E+04		2.9E+00
CYANIDE (Free)	1.0E+00	Aquatic Habitat Goal	1.7E+03	(Use soil gas)	1.0E+00
CYCLO-1,3,5-TRIMETHYLENE-2,4,6-TRINITRAMINE (RDX)	1.4E+03	Aquatic Habitat Goal	3.0E+04		1.4E+03
DALAPON	3.0E+03	Aquatic Habitat Goal	5.0E+04		3.0E+03

TABLE D-1d. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
DIBENZO(a,h)ANTHTRACENE	5.2E-01	Gross Contamination	5.2E-01		1.0E+00
DIBROMO,1,2- CHLOROPROPANE,3-	4.0E-02	Aquatic Habitat Goal	1.0E+02	(Use soil gas)	4.0E-02
DIBROMOCHLOROMETHANE	2.7E+02	Vapor Intrusion	5.0E+04	2.7E+02	1.1E+04
DIBROMOETHANE, 1,2-	1.2E+01	Vapor Intrusion	5.0E+04	1.2E+01	1.4E+03
DICHLOROBENZENE, 1,2-	1.0E+02	Gross Contamination	1.0E+02	6.5E+04	3.7E+02
DICHLOROBENZENE, 1,3-	3.7E+02	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	3.7E+02
DICHLOROBENZENE, 1,4-	1.1E+02	Gross Contamination	1.1E+02	3.0E+02	3.7E+02
DICHLOROBENZIDINE, 3,3-	2.5E+02	Aquatic Habitat Goal	1.6E+03		2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	6.0E-01	Aquatic Habitat Goal	4.5E+01		6.0E-01
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.1E+00	Aquatic Habitat Goal	2.0E+01		1.1E+00
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.3E-02	Aquatic Habitat Goal	2.8E+00		1.3E-02
DICHLOROETHANE, 1,1-	4.7E+01	Aquatic Habitat Goal	5.0E+04	7.4E+02	4.7E+01
DICHLOROETHANE, 1,2-	1.2E+02	Vapor Intrusion	5.0E+04	1.2E+02	3.8E+04
DICHLOROETHYLENE, 1,1-	3.9E+03	Aquatic Habitat Goal	1.5E+04	5.1E+03	3.9E+03
DICHLOROETHYLENE, Cis 1,2-	4.3E+03	Vapor Intrusion	5.0E+04	4.3E+03	1.2E+04
DICHLOROETHYLENE, Trans 1,2-	2.6E+03	Gross Contamination	2.6E+03	3.9E+03	1.2E+04
DICHLOROPHENOL, 2,4-	3.0E+00	Gross Contamination	3.0E+00		6.7E+02
DICHLOROPHENOXYACETIC ACID (2,4-D)	2.0E+02	Aquatic Habitat Goal	5.0E+04		2.0E+02
DICHLOROPROPANE, 1,2-	1.0E+02	Gross Contamination	1.0E+02	2.1E+02	3.4E+03
DICHLOROPROPENE, 1,3-	2.6E+02	Aquatic Habitat Goal	5.0E+04	4.4E+02	2.6E+02
DIELDRIN	7.1E-01	Aquatic Habitat Goal	1.3E+02		7.1E-01
DIETHYLPHTHALATE	9.4E+02	Aquatic Habitat Goal	5.0E+04		9.4E+02
DIMETHYLPHENOL, 2,4-	2.7E+02	Aquatic Habitat Goal	4.0E+03	1.2E+06	2.7E+02
DIMETHYLPHTHALATE	9.4E+02	Aquatic Habitat Goal	5.0E+04		9.4E+02
DINITROBENZENE, 1,3-	1.1E+02	Aquatic Habitat Goal	5.0E+04		1.1E+02
DINITROPHENOL, 2,4-	2.3E+02	Aquatic Habitat Goal	5.0E+04		2.3E+02
DINITROTOLUENE, 2,4- (2,4-DNT)	1.1E+02	Aquatic Habitat Goal	5.0E+04		1.1E+02
DINITROTOLUENE, 2,6- (2,6-DNT)	1.1E+02	Aquatic Habitat Goal	5.0E+04		1.1E+02
DIOXANE, 1,4-	5.0E+04	Gross Contamination	5.0E+04		3.4E+06
DIOXINS (TEQ)	3.0E-03	Aquatic Habitat Goal	6.0E-02		3.0E-03
DIURON	2.0E+02	Aquatic Habitat Goal	2.1E+04		2.0E+02
ENDOSULFAN	3.4E-02	Aquatic Habitat Goal	2.3E+02		3.4E-02
ENDRIN	3.7E-02	Aquatic Habitat Goal	1.3E+02		3.7E-02
ETHANOL	5.0E+04	Gross Contamination	5.0E+04		
ETHYLBENZENE	3.0E+02	Gross Contamination	3.0E+02	5.2E+03	4.3E+02
FLUORANTHENE	4.0E+01	Aquatic Habitat Goal	1.3E+02		4.0E+01
FLUORENE	3.0E+02	Aquatic Habitat Goal	9.5E+02	1.9E+03	3.0E+02
GLYPHOSATE	6.0E+02	Aquatic Habitat Goal	5.0E+04		6.0E+02
HEPTACHLOR	5.3E-02	Aquatic Habitat Goal	9.0E+01		5.3E-02
HEPTACHLOR EPOXIDE	5.3E-02	Aquatic Habitat Goal	1.0E+02		5.3E-02
HEXACHLOROBENZENE	3.1E+00	Gross Contamination	3.1E+00		6.0E+00
HEXACHLOROBUTADIENE	1.1E+01	Aquatic Habitat Goal	6.0E+01		1.1E+01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	1.6E-01	Aquatic Habitat Goal	4.0E+03		1.6E-01
HEXACHLOROETHANE	1.0E+02	Gross Contamination	1.0E+02		3.1E+02
HEXAZINONE	5.0E+04	Aquatic Habitat Goal	5.0E+04		5.0E+04

TABLE D-1d. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
INDENO(1,2,3-cd)PYRENE	9.2E-02	Aquatic Habitat Goal	9.5E-02		9.2E-02
ISOPHORONE	4.3E+03	Aquatic Habitat Goal	5.0E+04		4.3E+03
LEAD	2.9E+01	Aquatic Habitat Goal	5.0E+04		2.9E+01
MERCURY	2.1E+00	Aquatic Habitat Goal	3.0E+01	(Use soil gas)	2.1E+00
METHOXYCHLOR	3.0E-02	Aquatic Habitat Goal	5.0E+01		3.0E-02
METHYL ETHYL KETONE	1.4E+04	Aquatic Habitat Goal	5.0E+04	1.5E+08	1.4E+04
METHYL ISOBUTYL KETONE	1.7E+02	Aquatic Habitat Goal	1.3E+04	1.9E+07	1.7E+02
METHYL MERCURY	3.0E-03	Aquatic Habitat Goal	5.0E+04		3.0E-03
METHYL TERT BUTYL ETHER	1.8E+03	Gross Contamination	1.8E+03	2.1E+04	5.3E+04
METHYLENE CHLORIDE	3.1E+03	Vapor Intrusion	5.0E+04	3.1E+03	1.1E+04
METHYLNAPHTHALENE, 1-	1.0E+02	Gross Contamination	1.0E+02	1.1E+04	3.0E+02
METHYLNAPHTHALENE, 2-	1.0E+02	Gross Contamination	1.0E+02	2.5E+04	3.0E+02
MOLYBDENUM	2.4E+02	Aquatic Habitat Goal	5.0E+04		2.4E+02
NAPHTHALENE	2.1E+02	Gross Contamination	2.1E+02	2.5E+03	7.7E+02
NICKEL	5.0E+00	Aquatic Habitat Goal	5.0E+04		5.0E+00
NITROBENZENE	2.0E+03	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	2.0E+03
NITROGLYCERIN	1.4E+02	Aquatic Habitat Goal	5.0E+04		1.4E+02
NITROTOLUENE, 2-	7.5E+03	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	7.5E+03
NITROTOLUENE, 3-	3.8E+03	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	3.8E+03
NITROTOLUENE, 4-	3.3E+03	Aquatic Habitat Goal	5.0E+04		3.3E+03
PENTACHLOROPHENOL	1.3E+01	Aquatic Habitat Goal	5.9E+03		1.3E+01
PENTAERYTHRITOLTETRANITRATE (PETN)	2.2E+04	Gross Contamination	2.2E+04		4.3E+04
PERCHLORATE	6.0E+02	Aquatic Habitat Goal	5.0E+04		6.0E+02
PHENANTHRENE	7.7E+00	Aquatic Habitat Goal	4.1E+02	(Use soil gas)	7.7E+00
PHENOL	3.4E+03	Aquatic Habitat Goal	5.0E+04		3.4E+03
POLYCHLORINATED BIPHENYLS (PCBs)	2.0E+00	Aquatic Habitat Goal	1.6E+01		2.0E+00
PROPICONAZOLE	2.6E+02	Aquatic Habitat Goal	5.0E+04		2.6E+02
PYRENE	2.0E+00	Aquatic Habitat Goal	6.8E+01	1.4E+02	2.0E+00
SELENIUM	2.0E+01	Aquatic Habitat Goal	5.0E+04		2.0E+01
SILVER	1.0E+00	Aquatic Habitat Goal	5.0E+04		1.0E+00
SIMAZINE	1.0E+01	Aquatic Habitat Goal	3.1E+03		1.0E+01
STYRENE	1.0E+02	Aquatic Habitat Goal	1.1E+02	3.1E+05	1.0E+02
TERBACIL	2.3E+04	Aquatic Habitat Goal	5.0E+04		2.3E+04
tert-BUTYL ALCOHOL	5.0E+04	Gross Contamination	5.0E+04	(Use soil gas)	1.8E+05
TETRACHLOROETHANE, 1,1,1,2-	3.1E+03	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	3.1E+03
TETRACHLOROETHANE, 1,1,2,2-	1.6E+02	Vapor Intrusion	5.0E+03	1.6E+02	3.0E+03
TETRACHLOROETHYLENE	1.4E+02	Vapor Intrusion	3.0E+03	1.4E+02	1.8E+03
TETRACHLOROPHENOL, 2,3,4,6-	1.0E+01	Aquatic Habitat Goal	1.2E+04		1.0E+01
TETRANITRO-1,3,5,7-TETRAAZOCYCLOOCTANE (HMX)	1.9E+03	Aquatic Habitat Goal	5.0E+04		1.9E+03
THALLIUM	4.7E+02	Aquatic Habitat Goal	5.0E+04		4.7E+02
TOLUENE	4.0E+02	Gross Contamination	4.0E+02	5.3E+05	5.8E+03
TOXAPHENE	2.1E-01	Aquatic Habitat Goal	1.4E+02		2.1E-01
TPH (gasolines)	5.0E+03	Aquatic Habitat Goal	5.0E+03	(Use soil gas)	5.0E+03
TPH (middle distillates)	2.5E+03	Aquatic Habitat Goal	2.5E+03	(Use soil gas)	2.5E+03
TPH (residual fuels)	2.5E+03	Aquatic Habitat Goal	2.5E+03		2.5E+03

TABLE D-1d. GROUNDWATER ACTION LEVELS
(Groundwater IS NOT a current or potential drinking water resource)
(Surface water body IS NOT located within 150m of release site)
(ug/l)

CONTAMINANT	[1]Final Groundwater Action Level	Basis	Gross Contamination (Odors, etc.) Table G-2	Vapor Intrusion Into Buildings Table C-1a	Aquatic Habitat Impacts (acute) Table D-4a
TRICHLOROBENZENE, 1,2,4-	1.6E+02	Aquatic Habitat Goal	2.5E+04	2.0E+03	1.6E+02
TRICHLOROETHANE, 1,1,1-	6.0E+03	Aquatic Habitat Goal	5.0E+04	2.7E+05	6.0E+03
TRICHLOROETHANE, 1,1,2-	3.0E+02	Vapor Intrusion	5.0E+04	3.0E+02	6.0E+03
TRICHLOROETHYLENE	4.8E+02	Vapor Intrusion	5.0E+04	4.8E+02	7.0E+02
TRICHLOROPHENOL, 2,4,5-	1.0E+02	Aquatic Habitat Goal	2.0E+03		1.0E+02
TRICHLOROPHENOL, 2,4,6-	4.9E+02	Aquatic Habitat Goal	1.0E+03		4.9E+02
TRICHLOROPHENOXYACETIC ACID, 2,4,5- (2,4,5-T)	6.9E+02	Aquatic Habitat Goal	5.0E+04		6.9E+02
TRICHLOROPHENOXYPROPIONIC ACID, 2,4,5- (2,4,5-TP)	3.0E+01	Aquatic Habitat Goal	5.0E+04		3.0E+01
TRICHLOROPROPANE, 1,2,3-	1.4E+02	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	1.4E+02
TRICHLOROPROPENE, 1,2,3-	2.2E+00	Aquatic Habitat Goal	5.0E+04	(Use soil gas)	2.2E+00
TRIFLURALIN	2.0E+01	Aquatic Habitat Goal	9.2E+01		2.0E+01
TRINITROBENZENE, 1,3,5-	1.4E+02	Aquatic Habitat Goal	5.0E+04		1.4E+02
TRINITROPHENYLMETHYLNITRAMINE, 2,4,6- (TETRYL)	1.5E+02	Aquatic Habitat Goal	3.7E+04		1.5E+02
TRINITROTOLUENE, 2,4,6- (TNT)	5.7E+02	Aquatic Habitat Goal	5.0E+04		5.7E+02
VANADIUM	1.9E+01	Aquatic Habitat Goal	5.0E+04		1.9E+01
VINYL CHLORIDE	2.1E+01	Vapor Intrusion	3.4E+04	2.1E+01	7.8E+02
XYLENES	1.0E+03	Aquatic Habitat Goal	5.3E+03	1.6E+05	1.0E+03
ZINC	2.2E+01	Aquatic Habitat Goal	5.0E+04		2.2E+01

Notes:

1. Lowest of action levels for gross contamination, vapor intrusion and aquatic habitat impacts. Used to develop soil leaching action levels for protection of groundwater quality.

TPH -Total Petroleum Hydrocarbons. See text for discussion of different TPH categories.

Gross Contamination: Odor threshold, 1/2 solubility or 50000 ug/L maximum, whichever is lower. Intended to limit general groundwater resource degradation.

Vapor Intrusion: Addresses potential emission of volatile chemicals from groundwater into buildings and subsequent impact on indoor air. Assumes moderately permeable, sandy soil or fill material immediately beneath building slab and unrestricted ("residential") land use (refer to Chapter 2).

Aquatic Habitat Impacts: Addresses potential discharge of groundwater to estuarine aquatic habitat and subsequent impact on aquatic life; dilution of groundwater upon discharge to surface water not considered, in order to take into account potential impacts to benthic organisms (see Chapter 2).

Review of aquatic ecotoxicty data for ethanol underway. Based on preliminary review of available data, chronic toxicity screening levels likely to be significantly greater than ceiling level of 50,000 ug/L (refer to USEPA 2003b, ECOTOX database).

Method reporting limits and background concentrations replace final screening level as appropriate.

EPA National Primary Drinking Water Standards

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Acrylamide	TT[8]	Nervous system or blood problems;	Added to water during sewage/wastewater increased risk of cancer treatment	zero
OC	Alachlor	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
R	Alpha particles	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
IOC	Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
IOC	Arsenic	0.010 as of 1/23/06	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass & electronics production wastes	0
IOC	Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
OC	Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
IOC	Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
OC	Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
OC	Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
IOC	Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
R	Beta particles and photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
DBP	Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
IOC	Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
OC	Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04
OC	Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
D	Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes	MRDLG=4[1]

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	zero
D	Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	MRDLG=4[1]
D	Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants & young children: nervous system effects	Water additive used to control microbes	MRDLG=0.8[1]
DBP	Chlorite	1.0	Anemia; infants & young children: nervous system effects	Byproduct of drinking water disinfection	0.8
OC	Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	0.1
IOC	Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	0.1
IOC	Copper	TT[7]; Action Level = 1.3	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	1.3
M	*Cryptosporidium*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
IOC	Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	0.2
OC	2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	0.07
OC	Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	0.2
OC	1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	zero
OC	o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	0.6
OC	p-Dichlorobenzene	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories	0.075
OC	1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	0.007
OC	cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	0.07
OC	trans-1,2-Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	0.1
OC	Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories	zero
OC	1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	Di(2-ethylhexyl) adipate	0.4	Weight loss, live problems, or possible reproductive difficulties	Discharge from chemical factories	0.4
OC	Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	zero
OC	Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	0.007
OC	Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	zero
OC	Diquat	0.02	Cataracts	Runoff from herbicide use	0.02
OC	Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	0.1

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Endrin	0.002	Liver problems	Residue of banned insecticide	0.002
OC	Epichlorohydrin	TT[8]	Increased cancer risk, and over a long period of time, stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	zero
OC	Ethylbenzene	0.7	Liver or kidneys problems	Discharge from petroleum refineries	0.7
OC	Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	zero
IOC	Fluoride	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
M	*Giardia lamblia*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
DBP	Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
OC	Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
M	Heterotrophic plate count (HPC)	TT[3]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a
OC	Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	zero
OC	Hexachlorocyclopentadien e	0.05	Kidney or stomach problems	Discharge from chemical factories	0.05
IOC	Lead	TT[7]; Action Level = 0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	zero
M	*Legionella*	TT[3]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	zero
OC	Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens	0.0002
IOC	Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	0.002
OC	Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock	0.04
IOC	Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	10
IOC	Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
OC	Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood preserving factories	zero
OC	Picloram	0.5	Liver problems	Herbicide runoff	0.5
OC	Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
R	Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
IOC	Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines	0.05
OC	Simazine	0.004	Problems with blood	Herbicide runoff	0.004
OC	Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
OC	Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
IOC	Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
OC	Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
M	Total Coliforms (including fecal coliform and *E. coli*)	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5]	Coliforms are naturally present in the environment as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.	zero
DBP	Total Trihalomethanes (TTHMs)	0.10 0.080 after 12/31/03	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
OC	2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
OC	1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07
OC	1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	0.20
OC	1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	0.003
OC	Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	zero
M	Turbidity	TT[3]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing micro-organisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	n/a
R	Uranium	30 ug/L as of 12/08/03	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	zero

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	zero
M	Viruses (enteric)	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	10

NOTES

1 Definitions

- Maximum Contaminant Level Goal (MCLG)—The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- Maximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- Maximum Residual Disinfectant Level Goal (MRDLG)—The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- Maximum Residual Disinfectant Level (MRDL)—The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- Treatment Technique (TT)—A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- *Cryptosporidium* (as of 1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal.
- *Giardia lamblia*: 99.9% removal/inactivation
- Viruses: 99.99% removal/inactivation
- *Legionella:* No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.
- Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, for systems servicing >10,000, and January 14, 2005, for systems servicing <10,000, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.
- HPC: No more than 500 bacterial colonies per milliliter
- Long Term 1 Enhanced Surface Water Treatment (Effective Date: January 14, 2005); Surface water systems or (GWUDI) systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- Filter Backwash Recycling: The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

4 No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli* if two consecutive TC-positive samples, and one is also positive for *E. coli* fecal coliforms, system has an acute MCL violation.

5 Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

6 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

7 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

8 Each water system must certify, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05% dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent).

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

National Secondary Drinking Water Standards

National Secondary Drinking Water Standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

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Drinking Water Act, as amended (42 U.S.C. 300g–1). These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. At considerably higher concentrations of these contaminants, health implications may also exist as well as aesthetic degradation. The regulations are not Federally enforceable but are intended as guidelines for the States.

§ 143.2 Definitions.

(a) *Act* means the Safe Drinking Water Act as amended (42 U.S.C. 300f *et seq.)*.

(b) *Contaminant* means any physical, chemical, biological, or radiological substance or matter in water.

(c) *Public water system* means a system for the provision to the public of piped water for human consumption, if such a system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system. A public water system is either a ''community water system'' or a ''non-community water system.''

(d) *State* means the agency of the State or Tribal government which has jurisdiction over public water systems. During any period when a State does not have responsibility pursuant to section 1443 of the Act, the term ''State'' means the Regional Administrator, U.S. Environmental Protection Agency.

(e) *Supplier of water* means any person who owns or operates a public water system.

(f) *Secondary maximum contaminant levels* means SMCLs which apply to public water systems and which, in the judgement of the Administrator, are requisite to protect the public welfare. The SMCL means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of public water system. Contamimants added to the water under circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

[44 FR 42198, July 19, 1979, as amended at 53 FR 37412, Sept. 26, 1988]

§ 143.3 Secondary maximum contaminant levels.

The secondary maximum contaminant levels for public water systems are as follows:

Contaminant	Level
Aluminum	0.05 to 0.2 mg/l.
Chloride	250 mg/l.
Color	15 color units.
Copper	1.0 mg/l.
Corrosivity	Non-corrosive.
Fluoride	2.0 mg/l.
Foaming agents	0.5 mg/l.
Iron	0.3 mg/l.
Manganese	0.05 mg/l.
Odor	3 threshold odor number.
pH	6.5–8.5.
Silver	0.1 mg/l.
Sulfate	250 mg/l.
Total dissolved solids (TDS)	500 mg/l.
Zinc	5 mg/l.

These levels represent reasonable goals for drinking water quality. The States may establish higher or lower levels which may be appropriate dependent upon local conditions such as unavailability of alternate source waters or other compelling factors, provided that public health and welfare are not adversely affected.

[44 FR 42198, July 19, 1979, as amended at 51 FR 11412, Apr. 2, 1986; 56 FR 3597, Jan. 30, 1991]

§ 143.4 Monitoring.

(a) It is recommended that the parameters in these regulations should be monitored at intervals no less frequent than the monitoring performed for inorganic chemical contaminants listed in the National Interim Primary Drinking Water Regulations as applicable to community water systems. More frequent monitoring would be appropriate for specific parameters such as pH, color, odor or others under certain circumstances as directed by the State.

(b) Measurement of pH, copper and fluoride to determine compliance under

CONTAMINANTS REGULATED BY THE SAFE DRINKING WATER BRANCH (effective 3/4/09)

MICROBIOLOGICAL

Total Coliform Bacteria:

- 40 or more samples per month:
  No more than 5.0% of the samples may be total coliform positive
- Less than 40 samples/month:
  No more than 1 sample/month may be total coliform positive.

Fecal Coliform or E. coli Bacteria:

An acute violation occurs when:
A total coliform positive routine is followed by a fecal coliform or E. coli positive repeat, OR
A fecal coliform or E. coli positive routine is followed by a total coliform positive repeat

CONTAMINANT	MCL (mg/l)
INORGANIC CHEMICALS	
Arsenic	0.01
Asbestos	7 million fibers per liter
Barium	2.
Cadmium	0.005
Chromium	0.1
Copper (Action Level)	1.3
Lead (Action Level)	0.015
Mercury	0.002
Nitrate (as Nitrogen)	10.
Nitrite (as Nitrogen)	1.
Total Nitrate & Nitrite (as Nitrogen)	10.
Selenium	0.05
Fluoride	4.0
Antimony	0.006
Beryllium	0.004
Cyanide (as free Cyanide)	0.2
Thallium	0.002

DISINFECTION BYPRODUCTS	
(only Subpart H & P systems with population >10,000 until 1/1/04)	
Total trihalomethanes (sum of chloroform, bromoform, bromodichloromethane, dibromochloromethane)	0.080
Total Haloacetic Acids (sum of mono-, di-, trichloroacetic acids and mono- and dibromoacetic acids.	0.060
Chlorite (usually formed under ClO_2 use)	1.0
Bromate (brominated waters using ozone)	0.010

RADIONUCLIDES	
(applies to all community water systems)	
Gross alpha particle	15 pCi/l
Combined radium 226/228	5 pCi/l
Uranium	30 µg/l
Beta/photon emitters (applies only to systems using surface water with populations > 100,000)	4 mrem/yr

CONTAMINANT	MCL, (mg/l)
ORGANIC CHEMICALS	
Volatile Organic Chemicals	
Benzene	0.005
Carbon Tetrachloride	0.005
Chlorobenzene	0.1
o-Dichlorobenzene	0.6
para-Dichlorobenzene	0.075
1,2-Dichloroethane	0.005
1,1-Dichloroethylene	0.007
cis-1,2-Dichloroethylene	0.07
trans-1,2-Dichloroethylene	0.1
DCP (1,2-Dichloropropane)	0.005
Ethylbenzene	0.7
Styrene	0.1
Tetrachloroethylene	0.005
Toluene	1.
1,1,1-Trichloroethane	0.2
Trichloroethylene	0.005
TCP (1,2,3-Trichloropropane)	0.0006
Vinyl Chloride	0.002
Xylenes (total)	10.
Dichloromethane	0.005
1,2,4-Trichlorobenzene	0.07
1,1,2-Trichloroethane	0.005
Synthetic Organic Chemicals	
Alachlor	0.002
Atrazine	0.003
Carbofuran	0.04
Chlordane	0.002
DBCP (Dibromochloropropane)	0.00004
2,4-D	0.07
EDB (Ethylene Dibromide)	0.00004
Heptachlor	0.0004
Heptachlor Epoxide	0.0002
Lindane	0.0002
Methoxychlor	0.04
Pentachlorophenol	0.001
Toxaphene	0.003
2,4,5-TP (Silvex)	0.05
Benzo(a)pyrene	0.0002
Dalapon	0.2
Di(2-ethylhexyl) adipate	0.4
Di(2-ethylhexyl) phthalate	0.006
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Endrin	0.002
Glyphosate	0.7
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Oxamyl (Vydate)	0.2
Picloram	0.5
Simazine	0.004
2,3,7,8-TCDD (Dioxin)	3 X 10 -8

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(c) Underground tanks shall be exempted from the requirements of subsection (a) if the total volume of volatile organic compounds added to and taken from a tank annually does not exceed twice the volume of the tank. [Eff 11/26/93; comp 10/26/98; comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7416) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7416)

Historical note: §11-60.1-39 is based substantially upon §11-60-10. [Eff 11/29/82; am, ren §11-60-10 and comp 4/14/86; am and comp 6/29/92; R 11/26/93]

§11-60.1-40 Volatile organic compound water separation. No person shall use any single or multiple compartment volatile organic compound water separator which receives effluent water containing two hundred gallons (seven hundred sixty liters) or more of any volatile organic compound a day from any equipment that is processing, refining, treating, storing, or handling volatile organic compounds having a Reid vapor pressure of 0.5 pounds per square inch or greater unless such compartment is equipped with a properly installed vapor loss control device described as follows and which is in good working order, and in operation:

(1) A container having all openings sealed which totally encloses the liquid content. All gauging and sampling devices shall be gas-tight except when gauging or sampling is taking place;

(2) A container equipped with a floating roof, consisting of a pontoon type roof, double deck-type roof, or internal floating cover roof, which will rest on the surface of the liquid contents and be equipped with a closure seal or seals to close the space between the roof edge and container wall. All gauging and sampling devices shall be

gas-tight except when gauging or sampling is taking place;

(3) A container equipped with a vapor recovery system consisting of a vapor gathering system capable of collecting the volatile organic compound vapors and gases discharged, and a vapor disposal system capable of processing such volatile organic compound vapors and gases to prevent their emission to the atmosphere. All container gauging and sampling devices shall be gas-tight except when gauging and sampling is taking place; or

(4) A container having other equipment of equal efficiency for purposes of air pollution control as may be approved by the director. [Eff 11/26/93; comp 10/26/98; comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7416) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7416)

Historical note: §11-60.1-40 is based substantially upon §11-60-11. [Eff 11/29/82; am, ren §11-60-11 and comp 4/14/86; am and comp 6/29/92; R 11/26/93]

§11-60.1-41 Pump and compressor requirements. All pumps and compressors handling volatile organic compounds having a Reid vapor pressure of 1.5 pounds per square inch or greater which can be fitted with mechanical seals shall have mechanical seals or other equipment of equal efficiency for purposes of air pollution control as may be approved by the director. Pumps and compressors not capable of being fitted with mechanical seals, such as reciprocating pumps, shall be fitted with the best sealing system available for air pollution control given the particular design of pump or compressor as may be approved by the director. [Eff 11/26/93; comp 10/26/98; comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7416) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7416)

SUBCHAPTER 9

HAZARDOUS AIR POLLUTANT SOURCES

§11-60.1-171 <u>Definitions.</u> As used in this subchapter:

"Accidental release" means an unanticipated emission of a regulated substance or other extremely hazardous substance into the ambient air from a stationary source.

"Affected source" means the stationary source, the group of stationary sources, or the portion of a stationary source that is regulated by a relevant standard or other requirement established pursuant to Section 112 of the Act.

"Area source" means any stationary source of hazardous air pollutants that is not a major source but shall not include motor vehicles or nonroad vehicles subject to regulation approved pursuant to Title II of the Act.

"Carcinogenic hazardous air pollutant" means any hazardous air pollutant recognized as known, probable, or potential human carcinogen by the EPA's Integrated Risk Information System (IRIS), or other documented studies or information by recognized authorities and approved by the director.

"Category" means any category of major sources and area sources of hazardous air pollutants listed pursuant to Section 112(c) of the Act.

“Commenced” as used in this subchapter means, with respect to construction or reconstruction of an affected source, that an owner or operator has undertaken a continuous program of construction or reconstruction or that an owner or operator has entered into a contractual obligation to undertake and complete, within a reasonable time, a continuous program of construction or reconstruction.

"Construction" means the on-site fabrication, erection, or installation of an affected source as defined in 40 CFR §63.2.

"EPA risk assessment guidelines" means the U.S. Environmental Protection Agency's Guidelines for Carcinogenic Risk Assessment, 51 FR 33992 (September 24, 1986).

"Emission standard" means a national standard, limitation, prohibition, or other regulation promulgated in 40 CFR Part 63 pursuant to Sections 112(d), 112(h), or 112(f) of the Act.

"Equivalent MACT" means the MACT emission limitation or requirements which are applicable to major sources of hazardous air pollutants and are approved by the director on a case-by-case basis, pursuant to Sections 112(g) or 112(j) of the Act.

"Existing source" means any affected source that is not a new source as defined in this subchapter.

"MACT" means maximum achievable control technology.

"New source", unless otherwise defined in an applicable Section 112 standard, means any affected source which is:

(1) Major, or located within a major source of hazardous air pollutants, and in a category or subcategory for which construction or reconstruction is commenced after the Section 112(j) deadline, or after the Administrator proposes a relevant emission standard pursuant to Sections 112(d) or (h) of the Act, whichever comes first;

(2) Major, subject to 112(g) of the Act, and for which construction or reconstruction commenced after January 27, 1997; or

(3) Nonmajor, in a category or subcategory, and for which construction or reconstruction is commenced after the Administrator first proposes a relevant emission standard pursuant to Section 112(d) or (h) of the Act.

"Reconstruction", unless otherwise defined in an applicable Section 112 standard, means the replacement of components of an affected or a previously unaffected stationary source to such an extent that:

(1) The fixed capital cost of the new components exceeds fifty per cent of the fixed capital cost that would be required to construct a comparable new source; and

(2) It is technologically and economically feasible for the reconstructed source to meet the applicable MACT or equivalent MACT standard(s). Upon reconstruction, an affected source, or a stationary source that becomes an affected source, is subject to the applicable standards for new sources, including compliance dates, irrespective of any change in emissions of hazardous air pollutants from the source.

"Regulated substance" means a substance listed pursuant to Section 112(r)(3) of the Act.

"Risk management plan" means a plan to detect and prevent or minimize accidental releases of regulated substances from a stationary source, and to provide a prompt emergency response to any such releases in order to protect human health and the environment.

“Section 112(j)” means Section 112(j) of the Act.

“Section 112(j) deadline” means the date 18 months after the date by which a relevant standard is scheduled to be promulgated by the Administrator pursuant to Section 112(e) of the Act; except that for all major sources listed in the source category schedule for which a relevant standard is scheduled to be promulgated by November 15, 1994, the Section 112(j) deadline is November 15, 1996, and for all major sources listed in the source category schedule for which a relevant standard is scheduled to be promulgated by November 15, 1997, the Section 112(j) deadline is December 15, 1999.

"Stationary regulated substance source" means buildings, structures, equipment, installations, or substance-emitting stationary activities:

(1) Which belong to the same industrial group;

(2) Which are located on one or more contiguous properties;

(3) Which are under the control of the same person or persons under common control; and

(4) From which an accidental release may occur.

"Subcategory" means any subcategory of major sources and area sources of hazardous air pollutants listed pursuant to Section 112(c) of the Act.

"Threshold limit value" means the airborne concentration of a substance that, according to the American Conference of Governmental Industrial Hygienists, represents conditions under which nearly all workers may be repeatedly exposed day after day without adverse effects.

"Threshold limit value-time weighted average" means the threshold limit value for a normal eight-hour workday and a forty-hour workweek as specified in the TLV book.

"TLV-TWA" means threshold limit value-time weighted average.

"TLV book" means the "Documentation of the Threshold Limit Value and Biological Exposure Indices," sixth edition, published by the American Conference of Governmental Industrial Hygienists, Inc. [Eff 11/26/93; comp 10/26/98; am and comp 9/15/01; am and comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70)

§11-60.1-172 List of hazardous air pollutants. The following are hazardous air pollutants:

	CAS number	Chemical name
(1)	75070	Acetaldehyde
(2)	60355	Acetamide
(3)	75058	Acetonitrile
(4)	98862	Acetophenone
(5)	53963	2-Acetylaminofluorene
(6)	107028	Acrolein
(7)	79061	Acrylamide
(8)	79107	Acrylic acid
(9)	107131	Acrylonitrile

(10)	107051	Allyl chloride
(11)	92671	4-Aminobiphenyl
(12)	62533	Aniline
(13)	90040	o-Anisidine
(14)	1332214	Asbestos
(15)	71432	Benzene (including benzene from gasoline)
(16)	92875	Benzidine
(17)	98077	Benzotrichloride
(18)	100447	Benzyl chloride
(19)	92524	Biphenyl
(20)	117817	Bis(2-ethylhexyl)phtha-late (DEHP)
(21)	542881	Bis(chloromethyl)ether
(22)	75252	Bromoform
(23)	106990	1,3-Butadiene
(24)	156627	Calcium cyanamide
(25)	133062	Captan
(26)	63252	Carbaryl
(27)	75150	Carbon disulfide
(28)	56235	Carbon tetrachloride
(29)	463581	Carbonyl sulfide
(30)	120809	Catechol
(31)	133904	Chloramben
(32)	57749	Chlordane
(33)	7782505	Chlorine
(34)	79118	Chloroacetic acid
(35)	532274	2-Chloroacetophenone
(36)	108907	Chlorobenzene
(37)	510156	Chlorobenzilate
(38)	67663	Chloroform
(39)	107302	Chloromethyl methyl ether
(40)	126998	Chloroprene
(41)	1319773	Cresols/Cresylic acid (isomers and mixture)
(42)	95487	o-Cresol
(43)	108394	m-Cresol
(44)	106445	p-Cresol
(45)	98828	Cumene
(46)	94757	2,4-D, salts and esters
(47)	3547044	DDE

(48)	334883	Diazomethane
(49)	132649	Dibenzofurans
(50)	96128	1,2-Dibromo-3-chloro-propane
(51)	84742	Dibutylphthalate
(52)	106467	1,4-Dichlorobenzene(p)
(53)	91941	3,3-Dichlorobenzidene
(54)	111444	Dichloroethyl ether (Bis(2-chloroethyl)-ether)
(55)	542756	1,3-Dichloropropene
(56)	62737	Dichlorvos
(57)	111422	Diethanolamine
(58)	121697	N,N-Diethyl aniline (N,N-Dimethylaniline)
(59)	64675	Diethyl sulfate
(60)	119904	3,3-Dimethoxybenzidine
(61)	60117	Dimethyl aminoazobenzene
(62)	119937	3,3-Dimethyl benzidine
(63)	79447	Dimethyl carbamoyl chloride
(64)	68122	Dimethyl formamide
(65)	57147	1,1-Dimethyl hydrazine
(66)	131113	Dimethyl phthalate
(67)	77781	Dimethyl sulfate
(68)	534521	4,6-Dinitro-o-cresol, and salts
(69)	51285	2,4-Dinitrophenol
(70)	121142	2,4-Dinitrotoluene
(71)	123911	1,4-Dioxane (1,4-Diethyleneoxide)
(72)	122667	1,2-Diphenylhydrazine
(73)	106898	Epichlorohydrin (l-Chloro-2,3-epoxypropane)
(74)	106887	1,2-Epoxybutane
(75)	140885	Ethyl acrylate
(76)	100414	Ethyl benzene
(77)	51796	Ethyl carbamate (Urethane)
(78)	75003	Ethyl chloride (Chloroethane)
(79)	106934	Ethylene dibromide (Dibromoethane)
(80)	107062	Ethylene dichloride (1,2-Dichloroethane)
(81)	107211	Ethylene glycol
(82)	151564	Ethyleneimine (Aziridine)
(83)	75218	Ethylene oxide

(84)	96457	Ethylene thiourea
(85)	75343	Ethylidene dichloride (1,1-Dichloroethane)
(86)	50000	Formaldehyde
(87)	76448	Heptachlor
(88)	11874	Hexachlorobenzene
(89)	87683	Hexachlorobutadiene
(90)	77474	Hexachlorocyclo-pentadiene
(91)	67721	Hexachloroethane
(92)	82206	Hexamethylene-1,6-diisocyanate
(93)	680319	Hexamethylphosphoramide
(94)	110543	Hexane
(95)	302012	Hydrazine
(96)	7647010	Hydrochloric acid
(97)	7664393	Hydrogen fluoride (Hydrofluoric acid)
(98)	123319	Hydroquinone
(99)	78591	Isophorone
(100)	58899	Lindane (all isomers)
(101)	108316	Maleic anhydride
(102)	67561	Methanol
(103)	72435	Methoxychlor
(104)	74839	Methyl bromide (Bromomethane)
(105)	74873	Methyl chloride(Chloromethane)
(106)	71556	Methyl chloroform (1,1,1-Trichloroethane)
(107)	78933	Methyl ethyl ketone (2-Butanone)
(108)	60344	Methyl hydrazine
(109)	74884	Methyl iodide (Iodomethane)
(110)	108101	Methyl isobutyl ketone (Hexone)
(111)	624839	Methyl isocyanate
(112)	80626	Methyl methacrylate
(113)	1634044	Methyl tert butyl ether
(114)	101144	4,4-Methylene bis(2-chloroaniline)
(115)	75092	Methylene chloride (Dichloromethane)
(116)	101688	Methylene diphenyl diisocyanate (MDI)
(117)	101779	4,4-Methylenedianiline
(118)	91203	Naphthalene

(119)	98953	Nitrobenzene
(120)	92933	4-Nitrobiphenyl
(121)	100027	4-Nitrophenol
(122)	79469	2-Nitropropane
(123)	684935	N-Nitroso-N-methylurea
(124)	62759	N-Nitrosodimethylamine
(125)	59892	N-Nitrosomorpholine
(126)	56382	Parathion
(127)	82688	Pentachloronitrobenzene Quintobenzene)
(128)	87865	Pentachlorophenol
(129)	108952	Phenol
(130)	106503	p-Phenylenediamine
(131)	75445	Phosgene
(132)	7803512	Phosphine
(133)	7723140	Phosphorus
(134)	85449	Phthalic anhydride
(135)	1336363	Polychlorinated biphenyls- (Aroclors)
(136)	1120714	1,3-Propane sultone
(137)	57578	beta-Propiolactone
(138)	123386	Propionaldehyde
(139)	114261	Propoxur (Baygon)
(140)	78875	Propylene dichloride (1,2-Dichloropropane)
(141)	75569	Propylene oxide
(142)	75558	1,2-Propylenimine (2-Methylaziridine)
(143)	91225	Quinoline
(144)	106514	Quinone
(145)	100425	Styrene
(146)	96093	Styrene oxide
(147)	1746016	2,3,7,8-Tetrachlorodiben-zo-p-dioxin
(148)	79345	1,1,2,2-Tetrachloroethane
(149)	127184	Tetrachloroethylene (Perchloroethylene)
(150)	7550450	Titanium tetrachloride
(151)	108883	Toluene
(152)	95807	2,4-Toluene diamine
(153)	584849	2,4-Toluene diisocyanate

(154)	95534	o-Toluidine
(155)	8001352	Toxaphene (chlorinated camphene)
(156)	120821	1,2,4-Trichlorobenzene
(157)	79005	1,1,2-Trichloroethane
(158)	79016	Trichloroethylene
(159)	95954	2,4,5-Trichlorophenol
(160)	88062	2,4,6-Trichlorophenol
(161)	121448	Triethylamine
(162)	1582098	Trifluralin
(163)	540841	2,2,4-Trimethylpentane
(164)	108054	Vinyl acetate
(165)	593602	Vinyl bromide
(166)	75014	Vinyl
(167)	75354	Vinylidene chloride (1,1-Dichloroethylene)
(168)	1330207	Xylenes (isomers and mixture)
(169)	95476	o-Xylenes
(170)	108383	m-Xylenes
(171)	106423	p-Xylenes
(172)	0	Antimony Compounds
(173)	0	Arsenic Compounds (inorganic including arsine)
(174)	0	Beryllium Compounds
(175)	0	Cadmium Compounds
(176)	0	Chromium Compounds
(177)	0	Cobalt Compounds
(178)	0	Coke Oven Emissions
(179)	0	Cyanide Compounds [1]
(180)	0	Glycol ethers [2]
(181)	0	Lead Compounds
(182)	0	Manganese Compounds
(183)	0	Mercury Compounds
(184)	0	Fine mineral fibers [3]
(185)	0	Nickel Compounds
(186)	0	Polycylic Organic Matter [4]
(187)	0	Radionuclides (including radon) [5]
(188)	0	Selenium Compounds

NOTE: For all listings above which contain the word "compounds" and for glycol ethers, the following applies: Unless otherwise specified, these listings are defined as including any unique chemical substance that contains the named chemical (i.e., antimony, arsenic, etc.) as part of that chemical's infrastructure.

[1] X'CN where X = H' or any other group where a formal dissociation may occur. For example, KCN or Ca(CN)2.

[2] Includes mono- and di- ethers of ethylene glycol, diethylene glycol, and triethylene glycol R-(OCH2CH2)n-OR' where:

n = 1, 2, or 3
R = alkyl or aryl groups
R' = R, H, or groups which, when removed, yield glycol ethers with the structure: R-(OCH2CH)n-OH. Polymers are excluded from the glycol category.

[3] Includes mineral fiber emissions from facilities manufacturing or processing glass, rock, or slag fibers (or other mineral derived fibers) of average diameter one micrometer or less.

[4] Includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100°C.

[5] A type of atom which spontaneously undergoes radioactive decay. [Eff 11/26/93; comp 10/26/98; am and comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70)

§11-60.1-173 Applicability. The provisions of this subchapter are applicable to any stationary source which emits or has the potential to emit any hazardous air pollutant. [Eff 11/26/93; comp 10/26/98; comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70)

§11-60.1-174 <u>Maximum achievable control technology (MACT) emission standards.</u> (a) This section applies to an owner or operator of a major or area source of hazardous air pollutants that has or will have affected source(s) in a category or subcategory subject to a promulgated MACT emission standard. An owner or operator of an affected source shall comply with all applicable provisions of 40 CFR Part 63, entitled "National Emission Standards for Hazardous Air Pollutants for Source Categories," including the following subparts:

(1) Subpart A, General Provisions;
(2) Subpart D, Regulations Governing Compliance Extensions for Early Reductions of Hazardous Air Pollutants;
(3) Subpart H, National Emission Standards for Organic Hazardous Air Pollutants for Equipment Leaks;
(4) Subpart M, National Perchloroethlylene Air Emission Standards for Dry Cleaning Facilities;
(5) Subpart N, National Emission Standards for Chromium Emissions from Hard and Decorative Chromium Anodizing Tanks;
(6) Subpart O, Ethylene Oxide Emissions Standards for Sterilization Facilities;
(7) Subpart Q, National Emission Standards for Hazardous Air Pollutants for Industrial Process Cooling Towers;
(8) Subpart R, National Emission Standards for Gasoline Distribution Facilities (Bulk Gasoline Terminals and Pipeline Breakout Stations);
(9) Subpart T, National Emission Standards for Halogenated Solvent Cleaning;
(10) Subpart U, National Emission Standards for Hazardous Air Pollutant Emissions: Group I Polymers and Resins;
(11) Subpart W, National Emission Standards for Hazardous Air Pollutants for Epoxy Resins

Production and Non-Nylon Polyamides Production;
(12) Subpart Y, National Emission Standards for Marine Tank Vessel Loading Operations;
(13) Subpart CC, National Emission Standards for Hazardous Air Pollutants from Petroleum Refineries;
(14) Subpart DD, National Emission Standards for Hazardous Air Pollutants from Off-Site Waste and Recovery Operations;
(15) Subpart GG, National Emission Standards for Aerospace Manufacturing and Rework Facilities;
(16) Subpart II, National Emission Standards for Shipbuilding and Ship Repair (Surface Coating);
(17) Subpart JJ, National Emission Standards for Wood Furniture Manufacturing Operations;
(18) Subpart KK, National Emission Standards for the Printing and Publishing Industry;
(19) Subpart OO, National Emission Standards for Tanks-Level 1;
(20) Subpart PP, National Emission Standards for Containers;
(21) Subpart QQ, National Emission Standards for Surface Impoundments;
(22) Subpart RR, National Emission Standards for Individual Drain Systems;
(23) Subpart VV, National Emission Standards for Oil-Water Separators and Organic Water Separators;
(24) Subpart JJJ, National Emission Standards for Hazardous Air Pollutant Emissions: Group IV Polymers and Resins;
(25) Subpart UUU, National Emission Standards for Hazardous Air Pollutants for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units;

(26) Subpart VVV, National Emission Standards for Hazardous Air Pollutants: Publicly Owned Treatment Works;

(27) Subpart HHHH, National Emission Standards for Hazardous Air Pollutants for Wet-Formed Fiberglass Mat Production; and

(28) Subpart VVVV, National Emission Standards for Hazardous Air Pollutants for Boat Manufacturing.

(b) Each MACT emission standard (including emission limits, control, operational, and maintenance requirements, compliance dates, and associated recordkeeping, monitoring, testing, notification, and reporting requirements) is an applicable requirement of subchapter 5, Covered Sources. Any owner or operator who constructs, reconstructs, modifies, or operates an affected source is subject to the application and permitting requirements of subchapter 5.

(c) The deadlines for submitting the required initial notification, and applying for or obtaining a covered source permit to address the MACT emission standard are as follows:

(1) The owner or operator of a new affected source shall submit a complete covered source permit application for and obtain a covered source permit prior to commencing construction or reconstruction of an affected source, except as provided below.

(2) The owner or operator of a new major affected source for which construction or reconstruction had commenced, and initial startup had not occurred before the standard's effective date, shall submit a complete and timely covered source permit application within sixty calendar days after the standard's effective date. The covered source permit application may be used to fulfill the initial notification requirements of 40 CFR §63.9(b).

(3) The owner or operator of:

(A) an existing affected source;

(B) a new nonmajor affected source for which construction or reconstruction had commenced and initial startup had not occurred before the standard's effective date; or

(C) a new affected source for which construction or reconstruction had commenced and initial startup had occurred before the standard's effective date;

shall submit written notification to the director of being subject to the MACT emission standard within 120 calendar days after the effective date of the applicable standard or within 120 calendar days after the source becomes subject to the applicable standard. The owner or operator may submit an initial notification later than the deadline required above, if the applicable MACT standard sets a later deadline. Notification shall be provided pursuant to 40 CFR §63.9(b)(2). The owner or operator shall also submit a complete and timely covered source permit application within twelve months after the effective date of the standard, or within twelve months after the source becomes subject to the standard.

(d) In addressing the MACT emission standard, the owner or operator of an affected source shall provide as part of the covered source permit application, any other additional information listed in 40 CFR 63.5(d)(1)(ii), (2), and (3). [Eff 11/26/93; comp 10/26/98; am and comp 9/15/01; am and comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70)

§11-60.1-175 Equivalent maximum achievable control technology (MACT) limitation. (a) This section applies to:

(1) an owner or operator of a major source of hazardous air pollutants which includes one or more stationary sources that are within a source category or subcategory for which the Administrator has failed to promulgate an applicable emission standard under 40 CFR Part 63 by the section 112(j) deadline; and

(2) an owner or operator who constructs or reconstructs a major source (as defined in 40 CFR §63.41) of hazardous air pollutants after January 27, 1997, and an owner or operator of an area source that converts to a major source of hazardous air pollutants after January 27, 1997, unless the major source has been specifically regulated or exempted from regulation under a standard issued pursuant to section 112(d), 112(h), or 112(j) of the Act.

(b) An owner or operator subject to this section is subject to an equivalent MACT limitation and shall comply with the applicable provisions of 40 CFR Part 63, entitled National Emission Standards for Hazardous Air Pollutants for Source Categories:

(1) Subpart A, General Provisions; and

(2) Subpart B, Requirements for Control Technology Determinations for Major Sources in Accordance with Clean Air Act Sections 112(g) and 112(j) (40 CFR §63.40 to §63.44 and §63.50 to §63.56).

(c) The director shall determine, on a case-by-case basis, the equivalent MACT emission limitation in accordance with applicable provisions of 40 CFR Part 63, Subpart B, and impose any other requirements necessary to ensure the enforceability of the equivalent MACT emission limitation.

(d) Each equivalent MACT limitation (including emission limits, control, operational, and maintenance requirements, compliance dates, and any associated recordkeeping, monitoring, testing, notification, and reporting requirements) is an applicable requirement of subchapter 5, Covered Sources. Any owner or operator who constructs, reconstructs, modifies, or operates an affected source is subject to the application and permitting requirements of subchapter 5.

(e) An owner or operator subject to paragraph (a)(1) shall comply with the following deadlines for applying for and obtaining a covered source permit to address the equivalent MACT limitation:

(1) For existing sources:

(A) The owner or operator of a major source or an affected source within a major source shall submit a complete and timely covered source permit application by the Section 112(j) deadline.

(B) The owner or operator who reconstructs a major source or an affected source within a major source, and the owner or operator of an area source that becomes a major source by the addition or reconstruction of an affected source or by the increase in the source's potential to emit (e.g., increased hours of operation or fuel usage, etc.) shall submit a complete covered source permit application and obtain a covered source permit prior to reconstruction or conversion to a major source.

(C) The owner or operator of an area source that becomes major and subject to paragraph (a)(1) due to the Administrator establishing a lesser quantity emission rate for a "major source" under Section 112(a)(1) of the Act shall submit a complete and timely covered source permit application within six months from the date that the source becomes major.

(2) For new sources:

(A) The owner or operator who constructs or reconstructs a major source or an affected source within a major source, and the owner or operator of an area source that becomes a major source by the addition or reconstruction of an affected source or by the increase in the source's potential to emit (e.g., increased hours of operation or fuel usage, etc.) shall submit a complete covered source permit application and obtain a covered source permit prior to construction, reconstruction, or conversion to a major source.

(B) The owner or operator of an area source that becomes major and subject to paragraph (a)(1) due to the Administrator establishing a lesser quantity emission rate for a "major source" under Section 112(a)(1) of the Act shall submit a complete and timely covered source permit application within six months from the date that the source becomes major.

In addressing equivalent MACT, the owner or operator of the source shall provide, as part of the covered source permit application, any additional information required by 40 CFR §63.53.

(f) An owner or operator subject to paragraph (a)(2) who constructs or reconstructs a major source, and the owner or operator of an area source that becomes a major source by the increase in the source's potential to emit (e.g., increased hours of operation or fuel usage, etc.) shall submit a complete covered source permit application and obtain a covered source permit prior to construction, reconstruction, or conversion to a major source. In addressing equivalent MACT, the owner or operator of the affected major source shall provide, as part of the covered source permit application, any additional information required by 40 CFR §63.43(e). [Eff 11/26/93; comp 10/26/98; am and comp 9/15/01; am and comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70)

§11-60.1-176 REPEALED. [R 9/15/01]

§11-60.1-177 Early reduction. (a) Upon program approval and notwithstanding sections 11-60.1-174 and 11-60.1-175, the director may allow an existing source, for which the owner or operator demonstrates that the source has achieved a reduction pursuant to 40 CFR Part 63, Subpart D, to meet an alternative emission limitation reflecting that reduction in lieu of an emission limitation promulgated pursuant to Section 112(d) of the Act.

(b) The alternative emission limitation specified in subsection (a) shall be considered an applicable requirement pursuant to subchapter 5. [Eff 11/26/93; comp 10/26/98; comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Parts 63 and 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Parts 63 and 70)

§11-60.1-178 Accidental releases. The owner or operator of a stationary regulated substance source shall comply with any standard or other requirement concerning accidental releases, including the preparation, submittal, and implementation of a risk management plan pursuant to Section 112(r) of the Act. [Eff 11/26/93; comp 10/26/98; comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70)

§11-60.1-179 Ambient air concentrations of hazardous air pollutants. (a) No person shall emit or cause to emit from any stationary source, hazardous air pollutants in such quantities that result in, or contribute to, an ambient air concentration which endangers human health.

(b) The director shall not approve any application for a permit required by this chapter, for a new major source of hazardous air pollutants, or for the modification or reconstruction of any major source of hazardous air pollutants, or for any stationary source that the director has reason to believe that the emissions of hazardous air pollutants from the source may result in an unacceptable ambient air concentration, unless the owner or operator of the source, and except as provided in subsection (d), complies with one or more of the following:

(1) Demonstrate that the emissions of hazardous air pollutants from the source will not result in, or contribute to, any significant ambient air concentrations as defined in subsection (c); or

(2) Demonstrate that the applicable significant ambient air concentration in subsection (c) is inappropriate for the hazardous air pollutant in question and that the emissions of hazardous air pollutants from the source will not result in, or contribute to, any ambient air concentration which endangers human health. The demonstration shall include documented studies or information by recognized authorities on the specific health effects of such hazardous air pollutants and a detailed analysis, including a risk assessment, that demonstrates that the emissions from the sources will not endanger human health.

(c) For purposes of this subchapter, "significant ambient air concentration of any hazardous air pollutant" shall be defined as follows:

(1) For any non-carcinogenic hazardous air pollutant with a TLV-TWA, and except as provided in subsection (e), any eight-hour average ambient air concentration in excess of 1/100 of the TLV-TWA, and any annual

average ambient air concentration in excess of 1/420 of the TLV-TWA;

(2) For any non-carcinogenic hazardous air pollutant not having a TLV-TWA, any ambient air concentration greater than the concentration which the director determines to cause, to have the potential to cause, or to contribute to, the unreasonable endangerment of human health. The determination shall be made on a case-by-case basis, consider documented studies or information by recognized authorities on the specific health effects of such hazardous air pollutants, and include a reasonable margin of safety for the protection of the general public; or

(3) For any carcinogenic hazardous air pollutant, any ambient air concentration that may result in an excess individual lifetime cancer risk of more than ten in one million assuming continuous exposure for seventy years. The ambient air concentration of a carcinogenic hazardous air pollutant shall be determined by performing a risk assessment based on procedures consistent with EPA's risk assessment guidelines or other alternative risk assessment procedures approved by the director.

(d) The emission of any hazardous air pollutants from a stationary source shall be exempt from the provisions of subsection (b) if:

(1) The total allowable emissions of the hazardous air pollutant from the stationary source are below 0.1 pounds per hour; and

(2) The significant ambient air concentration for the hazardous air pollutant as determined in accordance with subsection (c) is greater than two hundred $\mu g/m^3$ for all applicable averaging periods.

(e) Notwithstanding subsection (c)(1), the director may at any time establish a lower concentration than the significant ambient air concentration specified in subsection (c)(1) if the director determines that such lower concentration is required for the protection of the public health or welfare. [Eff 11/26/93; comp 10/26/98; am and comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 70)

§11-60.1-180 National emission standards for hazardous air pollutants. (a) This section applies to an owner or operator of a major or area source of hazardous air pollutants that has or will have source(s) that emit designated hazardous air pollutants listed in 40 CFR Part 61. An owner or operator of a stationary source shall comply with all applicable provisions of 40 CFR Part 61, entitled National Emission Standards for Hazardous Air Pollutants, including the following subparts:

(1) Subpart A, General Provisions;
(2) Subpart C, National Emission Standard for Beryllium;
(3) Subpart D, National Emission Standard for Beryllium Rocket Motor Firing;
(4) Subpart E, National Emission Standard for Mercury;
(5) Subpart J, National Emission Standard for Equipment Leaks (Fugitive Emission Sources) of Benzene;
(6) Subpart V, National Emission Standard for Equipment Leaks (Fugitive Emission Sources);
(7) Subpart Y, National Emission Standard for Benzene Emissions From Benzene Storage Vessels;
(8) Subpart BB, National Emission Standard for Benzene Emissions from Benzene Transfer Operations; and
(9) Subpart FF, National Emission Standard for Benzene Waste Operations.

(b) Each emission standard in 40 CFR Part 61 (including emission limits, control, operational, and maintenance requirements, compliance dates, and associated recordkeeping, monitoring, testing, notification, and reporting requirements) is an applicable requirement of subchapter 5, Covered Sources. Any owner or operator who constructs, reconstructs, modifies, or operates an applicable source is subject to the application and permitting requirements of subchapter 5. [Eff 11/26/93; comp 10/26/98; am and comp 9/15/01; comp 11/14/03] (Auth: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7412, 7416; 40 C.F.R. Part 61) (Imp: HRS §§342B-3, 342B-12; 42 U.S.C. §§7407, 7416; 40 C.F.R. Part 61)

JOB NAME	Red Hill Water Treatment				
JOB NO.	2008014	SHEET	1	OF	1
CALCULATED BY	HC	DATE	06/04/2009		
CHECKED BY		DATE			

Objective: To determine if a vapor recovery system is required for the treatment facility

Given

Q = 16 mgd Design Capacity

According to HAR §11-60.1-40, a vapor recovery system is required if

VOC water separator "receives effluent water containing two hundred gallons or more of any volatile organic compound a day from any equipment that is processing, refining, treating, storing, or handling volatile organic compounds having a Reid vapor pressure of 0.5 pounds per square inch or greater".

Since the current USTs contains JP-5 and F-76, and both fuels have Reid vapor pressure (RVP) equal to 0 at room temperature, no vapor recovery equipment is required.

JOB NAME	Red Hill Water Treatment				
JOB NO.	2008014	SHEET	1	OF	2
CALCULATED BY	HC	DATE	07/01/2009		
CHECKED BY		DATE			

Objective: To calculate if the emission of hazardous air pollutants from PTAs are under the exempt conditions by HAR §11-60.1-179 (d)

	Chemical	CAS Number	Solubility[1] 20-25°C mg/L	Henry's Constant[1] atm.m^3/mole	HDOH[2] EALs mg/L	EPA[3] MCL mg/L	PTA[4] Removal 90.0%	Est PTA[4] Infl. Conc. mg/L	PTA[4] Effl. Conc. mg/L	Air Pollutant Emitted lb/hour
	Petroleum									
x	* TPH (middle distillates)	-	-	-	1.00E-01	-	0.0%	5.00E-01	5.00E-01	n/a
x	TPH (gasolines)	-	-	-	1.00E-01	-	0.0%	5.00E-01	5.00E-01	n/a
	PAH (Semi-Volatile)									
x	Acenaphthene	83-32-9	3.90E+00	1.84E-04	2.00E-02	-	80.0%	5.00E-01	1.00E-01	n/a
x	Acenaphthylene	208-96-8	1.61E+01	1.40E-04	2.40E-01	-	80.0%	6.00E+00	1.20E+00	n/a
x	Anthracene	120-12-7	4.34E-02	5.56E-05	7.30E-04	-	0.0%	3.65E-03	3.65E-03	n/a
x	Benzo(a)Anthracene	56-55-3	9.40E-03	1.20E-05	2.70E-05	-	0.0%	1.35E-04	1.35E-04	n/a
x	Benzo(a)Pyrene	50-32-8	1.62E-03	4.57E-07	1.40E-05	2.00E-04	0.0%	7.00E-05	7.00E-05	n/a
x	Benzo(b)Fluoranthene	205-99-2	1.50E-03	6.57E-07	9.20E-05	-	0.0%	4.60E-04	4.60E-04	n/a
x	Benzo(g,h,i)Perylene	191-24-2	2.60E-04	3.31E-07	1.00E-04	-	0.0%	5.00E-04	5.00E-04	n/a
x	Benzo(k)Fluoranthene	207-08-9	8.00E-04	5.84E-07	4.00E-04	-	0.0%	2.00E-03	2.00E-03	n/a
x	Chrysene	218-01-9	2.00E-03	5.23E-06	3.50E-04	-	0.0%	1.75E-03	1.75E-03	n/a
x	Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	1.23E-07	9.20E-06	-	0.0%	4.60E-05	4.60E-05	n/a
x	Fluoranthene	206-44-0	2.60E-01	8.86E-06	4.00E-02	-	0.0%	2.00E-01	2.00E-01	n/a
x	Fluorene	86-73-7	1.69E+00	9.62E-05	2.40E-01	-	0.0%	1.20E+00	1.20E+00	n/a
x	Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	3.48E-07	9.20E-05	-	0.0%	4.60E-04	4.60E-04	n/a
x	* Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	5.80E-04	-	-	-	-	-	-
x	* Methylnaphthalene, 1-	90-12-0	2.58E+01	5.14E-04	4.70E-03	-	80.0%	1.18E-01	2.35E-02	n/a
x	* Methylnaphthalene, 2-	91-57-6	2.46E+01	5.18E-04	1.00E-02	-	80.0%	2.50E-01	5.00E-02	n/a
x	* Naphthalene	91-20-3	3.10E+01	4.40E-04	1.70E-02	-	80.0%	4.25E-01	8.50E-02	n/a
x	Phenanthrene	85-01-8	1.15E+00	4.23E-05	7.70E-03	-	0.0%	3.85E-02	3.85E-02	n/a
x	Pyrene	129-00-0	1.35E-01	1.19E-05	2.00E-03	-	0.0%	1.00E-02	1.00E-02	n/a
	VOC									
v	Benzene	71-43-2	1.79E+03	5.55E-03	5.00E-03	5.00E-03	99.0%	5.00E-01	5.00E-03	2.75E+00
x	Bromomethane	74-83-9	1.52E+04	7.34E-03	8.70E-03	-	90.0%	4.35E-01	4.35E-02	n/a
v	Ethylbenzene	100-41-4	1.69E+02	7.88E-03	3.00E-02	7.00E-01	99.0%	3.00E+00	3.00E-02	1.65E+01
v	Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.87E-04	5.00E-03	-	99.0%	5.00E-02	5.00E-04	2.75E-01
v	m-Xylene	108-38-3	1.61E+02	7.18E-03	-	-	90.0%	-	-	-
v	* Naphthalene	91-20-3	3.10E+01	4.40E-04	1.70E-02	-	90.0%	8.50E-01	8.50E-02	4.25E+00
v	o-Xylene	95-47-6	1.78E+02	5.18E-03	-	-	90.0%	-	-	-
x	p-Cymene	99-87-6	2.34E+01	1.10E-02	-	-	90.0%	-	-	n/a
v	Toluene	108-88-3	5.26E+02	6.64E-03	4.00E-02	1.00E+00	99.0%	4.00E+00	4.00E-02	2.20E+01
v	Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	1.42E-03	7.00E-02	7.00E-02	90.0%	3.50E+00	3.50E-01	1.75E+01
v	Trichloroethylene	79-01-6	1.28E+03	9.85E-03	5.00E-03	5.00E-03	99.0%	5.00E-01	5.00E-03	2.75E+00
v	Xylenes	1330-20-7	1.06E+02	6.63E-03	2.00E-02	1.00E+01	99.0%	2.00E+00	2.00E-02	1.10E+01

The total hazardous air pollutant emitted from PTA is 77.01 lbs/hr > 0.1 lbs/hr as defined in HAR §11-60.1-179(d)

According HAR 11-60.1, further investigation is required to demonstrate:

1) The emission of hazardous air pollutants from the source will not result in any significant ambient air concentrations as defined in HAR 11-60.1-179 (c);

or

2) The applicable significant ambient air concentration in section HAR 11-60.1-179 (c) is inappropriate for the hazardous air pollutant in question and that the emissions of hazardous air pollutants from the source will not result in any ambient air concentration which endangers human health.

Notes:

* Contaminant exceeds HDOH EALs. Quarterly Groundwater Monitoring Report.
v Contaminant defined as hazardous air pollutants in HAR §11-60.1-172.
x Contaminant not listed as hazardous air pollutants in HAR §11-60.1-172.
1 United States National Library of Medicine, National Institute of Health. http://www.nlm.nih.gov/
2 Hawaii Department of Health. Environmental Action Levels. Table D-1b.
3 Environmental Protection Agency. Contaminant MCLs.
4 Kawamura, Susumu. Integrated Design and Operation of Water Treatment Facilities, p.550. 2000. Removal rates range from 90% to 99.995%.
P. Vesiland and T Distefano, Controlling Environmental Pollution. Removal rate low for Henry's const less than 10^{-5} atm m^3/mol
Calculation see Table 4-3
5 VOC emission from PTA: $E = 5.004Q(C_i - C_o)/10^7$ where
E = Emission rate, lb/hr
C_i = VOC influent concentration, ug/L
C_o = VOC effluent concentration, ug/L
Q = Water flow rate (mgd) = 16 mgd = 11100 mgd
From Handbook of Environmental Engineering by Lawrence K Wang, Norman C Pereira, Yung-Tse Hung.
6 "-" data not available' "n/a" not applicable.

Appendix B

Equipment Calculations and Quotes

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time		Change in Time		Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	hh:mm:ss	hh:mm:ss	minutes	mgd	gpm	gallons	gallons	gpm
01/01/2008 03:45				0	0.0	0.00		
01/01/2008 03:50	0:05:00			6.037109	4192.4	20962.18		
01/01/2008 03:55	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:00	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:05	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:10	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:15	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:20	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:25	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:30	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:35	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:40	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:45	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:50	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 04:55	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:00	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:05	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:10	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:15	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:20	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:25	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:30	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:35	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:40	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:45	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:50	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 05:55	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:00	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:05	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:10	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:15	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:20	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:25	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:30	0:05:00			9.27138	6438.5	32192.29		

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time		Change in Time		Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	hh:mm:ss	hh:mm:ss	minutes	mgd	gpm	gallons	gallons	gpm
01/01/2008 06:35	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:40	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:45	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:50	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 06:55	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:00	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:05	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:10	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:15	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:20	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:25	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:30	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:35	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:40	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:45	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:50	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 07:55	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:00	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:05	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:10	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:15	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:20	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:25	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:30	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:35	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:40	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:45	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:50	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 08:55	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:00	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:05	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:10	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:15	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:20	0:05:00			9.27138	6438.5	32192.29		

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time		Change in Time		Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	**hh:mm:ss**	**hh:mm:ss**	**minutes**	**mgd**	**gpm**	**gallons**	**gallons**	**gpm**
01/01/2008 09:25	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:30	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:35	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:40	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:45	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:50	0:05:00			9.27138	6438.5	32192.29		
01/01/2008 09:55	0:05:00			5.692973	3953.5	19767.27		
01/01/2008 10:00	0:05:00			0.403487	280.2	1401.00		
01/01/2008 10:05	0:05:00	6:20:00	380.00	0	0.0	0.00	2359975.45	6210.46
01/02/2008 01:35				0	0.0	0.00		
01/02/2008 01:40	0:05:00			6.067231	4213.4	21066.77		
01/02/2008 01:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 01:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 01:55	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:00	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:05	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:10	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:15	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:20	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:25	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:30	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:35	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:40	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 02:55	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:00	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:05	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:10	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:15	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:20	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:25	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:30	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:35	0:05:00			9.29768	6456.7	32283.61		

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time	Change in Time			Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	hh:mm:ss	hh:mm:ss	minutes	mgd	gpm	gallons	gallons	gpm
01/02/2008 03:40	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 03:55	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:00	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:05	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:10	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:15	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:20	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:25	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:30	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:35	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:40	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 04:55	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:00	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:05	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:10	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:15	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:20	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:25	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:30	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:35	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:40	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 05:55	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:00	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:05	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:10	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:15	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:20	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:25	0:05:00			9.29768	6456.7	32283.61		

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time		Change in Time		Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	hh:mm:ss	hh:mm:ss	minutes	mgd	gpm	gallons	gallons	gpm
01/02/2008 06:30	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:35	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:40	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 06:55	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:00	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:05	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:10	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:15	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:20	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:25	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:30	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:35	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:40	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 07:55	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:00	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:05	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:10	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:15	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:20	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:25	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:30	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:35	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:40	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:45	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:50	0:05:00			9.29768	6456.7	32283.61		
01/02/2008 08:55	0:05:00			3.939192	2735.6	13677.75		
01/02/2008 09:00	0:05:00	7:25:00	445.00	0	0.0	0.00	2811135.08	6317.16
01/03/2008 10:50				0	0.0	0.00		
01/03/2008 10:55	0:05:00			6.066794	4213.1	21065.26		
01/03/2008 11:00	0:05:00			9.32391	6474.9	32374.69		

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time		Change in Time		Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	**hh:mm:ss**	**hh:mm:ss**	**minutes**	**mgd**	**gpm**	**gallons**	**gallons**	**gpm**
01/03/2008 11:05	0:05:00			9.32391	6474.9	32374.69		
01/03/2008 11:10	0:05:00			9.037963	6276.4	31381.82		
01/03/2008 11:15	0:05:00			8.89499	6177.1	30885.38		
01/03/2008 11:20	0:05:00			8.594543	5968.4	29842.16		
01/03/2008 11:25	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 11:30	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 11:35	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 11:40	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 11:45	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 11:50	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 11:55	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:00	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:05	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:10	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:15	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:20	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:25	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:30	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:35	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:40	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:45	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:50	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 12:55	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:00	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:05	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:10	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:15	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:20	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:25	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:30	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:35	0:05:00			8.44432	5864.1	29320.56		
01/03/2008 13:40	0:05:00			8.76304	6085.4	30427.22		
01/03/2008 13:45	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 13:50	0:05:00			8.9224	6196.1	30980.56		

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time	Change in Time			Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	hh:mm:ss	hh:mm:ss	minutes	mgd	gpm	gallons	gallons	gpm
01/03/2008 13:55	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:00	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:05	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:10	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:15	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:20	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:25	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:30	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:35	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:40	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:45	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:50	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 14:55	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:00	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:05	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:10	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:15	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:20	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:25	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:30	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:35	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:40	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:45	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:50	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 15:55	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:00	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:05	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:10	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:15	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:20	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:25	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:30	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:35	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:40	0:05:00			8.9224	6196.1	30980.56		

Appendix B-1 Sample of Pump Flow Rate Analysis

Date and Time		Change in Time		Instantaneous Flow				
mm/dd/yyyy hh:mm:ss	**hh:mm:ss**	**hh:mm:ss**	**minutes**	**mgd**	**gpm**	**gallons**	**gallons**	**gpm**
01/03/2008 16:45	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:50	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 16:55	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:00	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:05	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:10	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:15	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:20	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:25	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:30	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:35	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:40	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:45	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:50	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 17:55	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:00	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:05	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:10	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:15	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:20	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:25	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:30	0:05:00			8.9224	6196.1	30980.56		
01/03/2008 18:35	0:05:00			3.533675	2453.9	12269.70		
01/03/2008 18:40	0:05:00	7:50:00	470.00	0	0.0	0.00	2809148.14	5976.91

P.O. Box 5265, 3461 Route 22 East, Somerville, NJ 08876
Phone 908.526.1114, Fax 908.526.2881
www.branchenv.com

AIR STRIPPER SYSTEM
BASIS 99% MTBE
SPECIFICATION

Model No: 144T30H
Quantity: Eight (8) modules operating in parallel – Each module to be a Model 144T30H – Stripping Tower
Total Price for a Complete Set of Eight Modules: $1,950,000
All Pricing in US Dollars
Note: This is a "Budget Price Only"
FOB: Shop:
Terms:

Progress payments would be required based on a mutually agreed upon schedule

Estimated Delivery:

Allow 4 – 6 Weeks for Drawings and Documents
Allow 16 – 18 Weeks after Drawing Approval for Fabrication

Note: Actual delivery can be quicker depending on required schedule. Please advise us of delivery requirements before making a decision.

DIMENSIONS – See Attached Sketch

Gas Inlet: Screen @ fan	Gas Outlet: 72"
Liquid Inlet: 10"	
Tower Diameter: 12'	Height: 42'

*** Note:** Liquid Storage can be integrated into base if required and additional process fittings can be added if necessary

Vessel Connections:	Drain/Pump: 12"
	Manway: Two (2) 24"
Separator Type: High performance Chevron	
Packing Type: HiFlow or equal	Size: #2

Fan: Model BCA-490 equipped with a 60 Hp TEFC motor – One (1) fan per module for a total of eight (8) fans

MATERIALS OF CONSTRUCTION

Housing: Fiberglass
Fan: Epoxy coated Steel inside/outside
Transition Duct: Fiberglass

Approximate Weights: Shipping: 35,000# - each
Operating: 50,000# - each

CONSTRUCTION DESIGN

In General Accordance With: International Fiberglass standards including PS 15-69
Vessel Designed For: Maximum pressure created by fan
Hold Down Lugs: Included
***Note:** Unit to be rated for appropriate wind load and earthquake zone

OPERATING CONDITIONS

***Note:** Each module is rated for 2 million gallons per day
Liquid Inlet Rate: (2mgd)
Liquid Composition: Water containing VOC and MTBE
Inlet Air Flow Rate Capacity: 37,200 CFM - each
Inlet Temperature: 60°F
Gas Composition: Air used for stripping
Pressure Drop Across System: 6" WG

PERFORMANCE DATA

99+% Removal efficiency of MTBE

COMMENTS

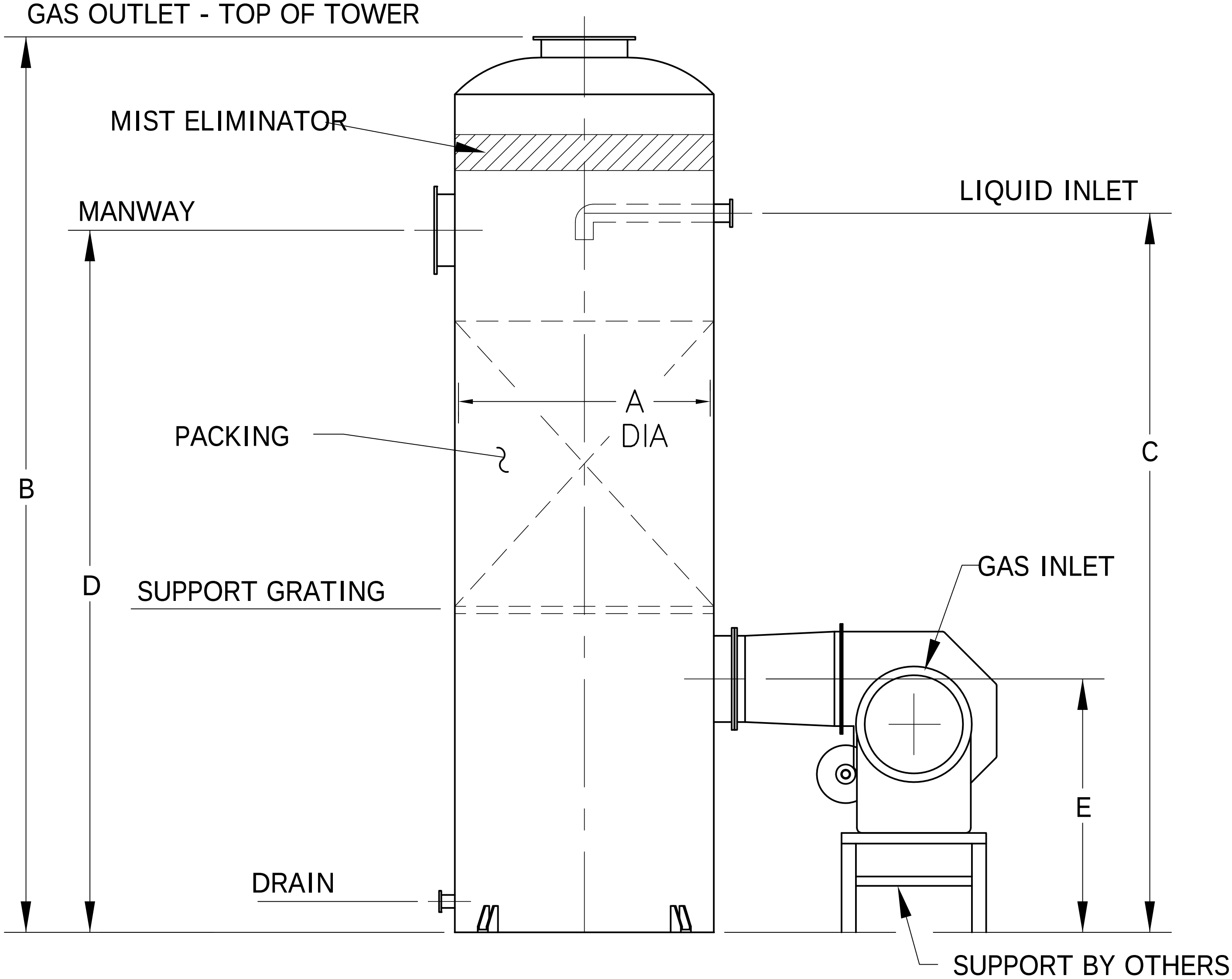
1. Each blower will be equipped with a 60 Hp TEFC motor but actually operates at approximately 47 BHP.

William Gilbert

Date: June 2, 2009

William Gilbert
BE09031010-Z

Quotation is Valid for 30 Days



ADDITIONAL PROCESS CONNECTIONS MAY NOT BE SHOWN
DIMENSIONS ARE APPROXIMATE

CONNECTION	SIZE	MARK	DIMENSION
GAS INLET	SCREEN @ FAN	A	12'-0"
GAS OUTLET	72"	B	42'-0"
LIQUID INLET	10"	C	38'-0"
DRAIN	12"	D	6' / 38'
MANWAYS	(2) 24"	E	4'-0"

BRANCH ENVIRONMENTAL CORP
P O BOX 5265
3461 ROUTE 22 EAST
SOMERVILLE, N. J. 08876

STRIPPING TOWER	
MODEL NO. 144T30H	
DWG. NO. BEP3725	
DWN BY A.R.	CHK BY
DATE 06/02/09	SHT 1 OF 1

Delta Cooling Towers, Inc.
41 Pine Street
Rockaway, New Jersey 07866-0315
Telephone 973-586-2201x116
Fax 973-586-2243
Email: sales@deltacooling.com
Web Address: www.deltacooling.com
Delta Cooling Towers

VANGUARD®

June 30, 2009

Wendy Chen
Civil Engineer
HDR | Hawaii Pacific Engineers, Inc
1132 Bishop Street, Suite 1003 | Honolulu, HI | 96813-2830
Phone: 808.697.6234 | Fax: 808.538.0445 | Email: wendy.chen@hdrinc.com

Subject: ***Budget Proposal***
16MGD VOC Air Stripper Project

Dear Ms. Chen,

Thank you for the opportunity to submit this Delta Air Stripper budget proposal for your consideration. In response to your request, Delta recommends the following equipment for this application.

Design Basis - (4) Towers at 2,775gpm per Tower @ 75°F
(4 towers in parallel for 16MGD total flow system)

Design Contaminant	Required Removal Efficiency	Calculated Removal Efficiency
Benzene	99%	99.9%+
Bromomethane	99%	99.9%+
Ethylbenzene	99%	99.9%+
MTBE	99%	99.0%
Toluene	99%	99.9%+
1,2,4-TCB	99%	99.9%+
Trichloroethylene	99%	99.9%+
Xylene	99%	99.9%+
Naphthalene	***99%***	***<10%***

Packed Tower Air Stripping System

Delta recommends Four (4) of our Vanguard® Model ΔS11-260DF air strippers for the subject application, each designed to remove Contaminants as shown at a total water flow rate of 2,775gpm @ 75 degrees F. Each stripper is a 132" diameter FRP column with 26'-0" of DeltaPAK Structured packing, **factory installed prior to shipment**. The tower shell will be fabricated from NSF Approved FRP and will include the necessary wall re-distribution rings and shell body flanges. ***Note Stainless Steel and Aluminum also Available!***

The other items included in Delta Cooling Towers, Inc.'s scope of supply for this project are (per tower):

- Each tower will include One (1) 75.0hp TEFC 230/460/3/60 blower/motor assembly designed for 37,100cfm @ 10.0"w.c.
- The blower will be supplied with the intake filter and louver, blower inlet and outlet flexible connection, blower discharge damper, and ductwork from the blower to the tower. All ductwork material is FRP.
- The tower column will be provided with the flanges, nozzles, connections and manways.
- The tower will also be supplied with the required internals; FRP packing support plates, PVC mist eliminators, and PVC inlet distribution systems.
- A 12" FRP influent pipe terminating at a flange approximately 5'-0" above the base of the stripper, and a 14"effluent flanged end FRP nozzle connection (side discharge).
- Sump high-level switch for flooding protection.
- Design of the tower anchor bolts and sleeves is by Delta Cooling Towers, Inc., the supply and installation of the bolts required are by others.
- All the necessary drawings, submittals for approval and O&M manuals.

The following items are specifically **excluded** for this proposal:

- Offloading or installation labor.
- Interconnecting piping and/or other flow control devices.
- Insulation Materials of any Type.
- Anchor Bolts.
- Controls or Instrumentation other than specifically listed above.
- Any and all taxes.

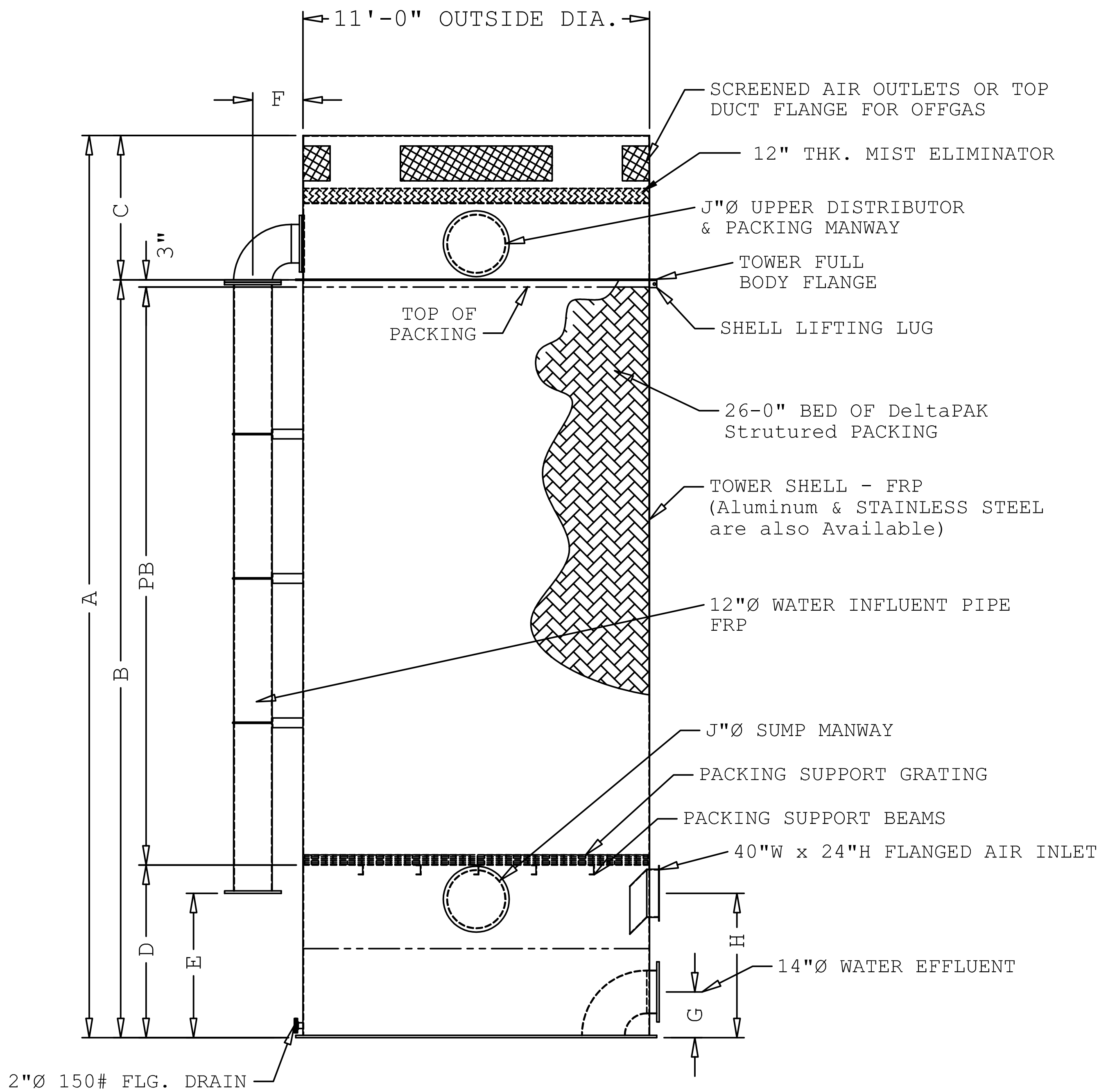
The **Per Tower** net price for the above (1) Air Stripper is **$265,000.00** FOB Philippi, W. VA., **freight pre-paid and add**. Shipment can be made approximately **10 weeks** after receipt of "Approved" submittals and authorization to proceed with fabrication. Please allow 1 to 2 weeks for preparation of submittals. Price is exclusive of any and all taxes.

Please feel free to contact the undersigned with any questions or comments. Thank you for your interest in Delta and its products, and for the opportunity to be of service.

Sincerely,

Joseph B. Homza, Jr.

Joseph B. Homza, Jr.
Vice President – Municipal Products Division



A	B	C	D	PB	E	F	G	H	J	K	L	M	N
36'-9"	32'-9"	4'-0"	6'-6"	26'-0"	5'-0"	18"	12"	5'-0"	24"	N/A	N/A	N/A	N/A

DELTA COOLING TOWERS, INC.

41 PINE STREET, ROCKAWAY, NJ 07866-0315

PH (973) 586-2201 FAX (973) 586-2243

VANGUARD®

TITLE VANGUARD® AIR STRIPPERS STANDARD SIDE DISCHARGE

PROSPECT: Red Hill WTP - HDR	**DWN BY** J.B. Homza
PROSPECT NUMBER: B09-019	**APPVD BY** J.C. Flaherty
SCALE NTS	**DWG NO.** B09-019 / (4) S11-260DF - 16MGD
DATE 6/30/09	

Delta Cooling Towers, Inc.

41 Pine Street · P.O. Box 315 · Rockaway, NJ 07866-0315
Phone: 973.586.2201 · Fax: 973.586.2243
Website: http://www.deltacooling.com

Delta-Pak® Structured Packing.

The PVC **Delta-Pak**® structured packing is a proprietary product, which offers unusually low air static pressure losses and provides high mass transfer efficiency.

The honeycomb-like construction allows for high air velocities for applications that demand it, and defers water loading "flooding points" well beyond typical maximum levels of random type packings.

Delta-Pak® structured packing is installed in homogeneous circular layers of nominal 12" and 6" high layers. The packing layers only weight about 2 lb/cu. ft. and can be easily handled.

Delta-Pak® structured packing can be cleaned chemically, as long as the limits of PVC corrosion and chemical resistance is respected.

If replacement of **Delta-Pak**® packing becomes necessary, the layers can be removed through the top of the air stripper column. The water distribution system can be removed to allow for packing removal. When the air stripper column is supplied as flanged sections, each packed section can be disassembled and lowered for easy access at grade level. The packing layers can be compressed in the radial direction if tight clearances are encountered, and will "spring back" to its original shape.

Do not step directly on the packing surface. Crushing of the edges of the PVC corrugations will inhibit proper air flow and water distribution, and as a result reduce performance.

If it is necessary to stand on the packing surface use a piece of plywood or similar protection to distribute weight over a greater surface. Maximum weight distribution is 80 lbs/sq. ft.

Do not stand on any packing inside a stripping tower unless it is absolutely necessary and unless proper judgment is exercised regarding the supporting capability of the packing.

Delta Cooling Towers, Inc.

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Phone: 973.586.2201 · Fax: 973.586.2243
Website: http://www.deltacooling.com

Packing. **Delta-Pak**®, used in all standard stripper models, is a high performance structured packing constructed of Type 1 PVC material protected against UV degradation.

Applicable data below is for air - water atmospheric system:

Surface area:	90 sq. ft./cu.ft.
Void space:	Higher than 98%
Open cross-section:	Higher than 98%
Maximum air flow before flooding, at 20 gpm/sq.ft.:	750 scfm/sq.ft. or higher
Static pressure loss at 20 gpm/sq.ft. and 500 scfm/ sq.ft. air flow:	0.10 in. W.C./ft. or lower
Orientation of corrugation:	Vertical ("see - through")
Nominal corrugation size:	Approx. 3/4 in.
"Channelling" characteristics:	No channeling occurs. Packing construction prevents any radial transfer of mass, due to its spirally wound configuration. Transfer in tangential direction is negligible. No redistribution devices are required.
"Clogging" and "fouling" characteristics:	The absence of any horizontally orientated surfaces reduces accumulation of precipitates and deposition of suspended solids. Most solids including precipitates pass freely through vertical corrugations.
Standard packing layer heights:	12.6 in. and 6.3 in.

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DELTA-PAK® STRUCTURED PACKING BENEFITS

HIGH IRON OR CALCIUM CONTENT

Concentrations of dissolved iron in ground water (in excess of 2 mg/l) has the potential to foul process equipment. High iron content water will combine with dissolved oxygen and precipitate, causing pumps, infiltration galleries, feed lines and packing media to foul.

Precipitation occurs primarily at the nozzle or inlet distribution area of an air stripper, where water mixes with the counter flowing air stream. Iron and calcium precipitate accumulates and hardens on all surfaces of packing. This precipitate will subsequently need to be removed, which is most effectively and economically removed in place. When properly cleaned, the particulate which sloughs off upper sections of random packings and may tend to "hang up" at lower levels of the packing bed. This accumulation, if not managed, can lead towards performance failure, media failure or even worse tower structural failure.

Delta-Pak® structured packing, since it does not have horizontal or angled surfaces, resists iron precipitate accumulation and therefore will operate efficiently for much longer periods between requiring chemical cleaning. In past applications **Delta-Pak**® structured packing has successfully performed four to six times longer than random packing it has replaced before having to be cleaned. The particulate which sloughs off the packing will flush straight through the media to the sump.

Delta-Pak® structured packing is recommended for applications where high iron or calcium levels are present in the process flow. Although the degree of fouling and frequency of required cleaning is site specific, it is generally recommended that
Delta-Pak® structured packing be used for iron or calcium levels above 2 mg/l.

From: Tuomala, Jayme M (WT) [Jayme.Tuomala@siemens.com]
Sent: Wednesday, July 15, 2009 4:49 AM
To: Galvan, Anthony G (WT); ESIKAILUA@aol.com
Cc: Koziol, Robert J (WT)
Subject: RE: Fwd: Red Hill Water Treatment
Attachments: GA Drawing.pdf; Equipment List Aluminum Forced.doc

We apologize for any delay, we have been OBE (Overcome By Events). But we have not forgotten about this project. We have sized up the aerators for a total flow rate of 11,200 gpm, for removal of VOC. With this flow rate we require five large aerators, each 12' sqft by 15' side height with 10' of loose fill internals. Refer to attached equipment list and drawing.

The units were sized to achieve 90% - 95% removal of Ethyl Benzene, which appears to be the limiting compound. But note our models do not include the following compounds so we don't know projected removals:

Trichlorobenzene 1,2,4
Xylenes (this is just a generic name)
Benzo(a)Pyrene

We are currently pricing up the aerators, but there are a few firm bids ahead of this project. I hope to complete by late this week or early next week.

Regards

Jayme Tuomala
Proposals Manager
Siemens Water Technologies Corp.
725 Wooten Road
Colorado Springs, CO 80915
Phone: 719-622-5343
FAX: 719-622-5399

email: jayme.tuomala@siemens.com

Click here to view the NEW Vantage(tm) NF/RO Systems

Click here to see the Trident(r) HS system, the latest in package water treatment technology

-----Original Message-----
From: Galvan, Anthony G (WT)
Sent: Tuesday, July 14, 2009 9:17 PM
To: 'ESIKAILUA@aol.com'; Tuomala, Jayme M (WT)
Cc: Koziol, Robert J (WT)
Subject: Re: Fwd: Red Hill Water Treatment

Scotty,
We been swamped with projects....anyway, Jayme is working on this one.
Jayme, please let Scotty know the response time.

Thanks!
Tony

-----Original Message-----
From: ESIKAILUA@aol.com <ESIKAILUA@aol.com>
To: Galvan, Anthony G (WT)
CC: Lscottesi@aol.com <Lscottesi@aol.com>; byoungesi@aol.com <byoungesi@aol.com>; Iopedalesi@aol.com <Iopedalesi@aol.com>; Tallering, Mike (WT)
Sent: Tue Jul 14 22:41:25 2009
Subject: Fwd: Red Hill Water Treatment

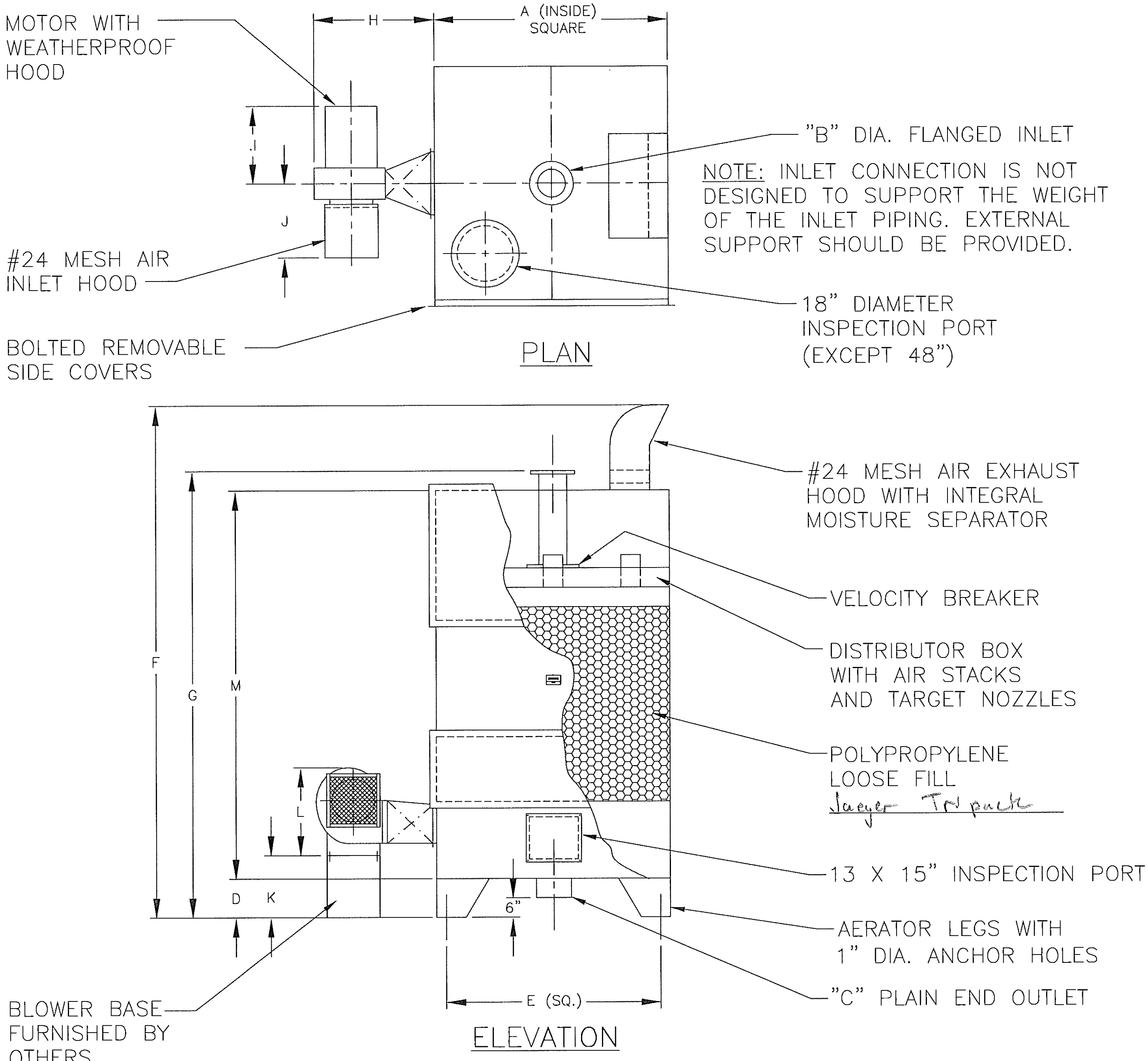
Tony:

Please advise the status of this inquiry.........Mahalo. Scotty.

(5 required)

GENERAL FILTER
ALUMINUM FORCED DRAFT AERATOR

48" SQ. AND LARGER UNITS
GAS STRIPPING



NOTE: CONFIGURATION SHOWN IS STANDARD

A	B	C	D	E	F	G
12'-0"	16"	24"	15"	11'-6"	19'-8 1/2"	16'-9"
H	I	J	K	L	M	
7'-6"	3'-8"	4'-9"	1'-1 1/2"	5'-9"	15'-0"	

PERFORMANCE DATA						
AERATOR CAPACITY (GPM)	BLOWER CHACTERISTICS			MOTOR STARTER: BY OTHERS		
	MODEL	SCFM	HP	VOLTS	PHASE	FREQ.
2,240	B 365	13,500	7 1/2	460/230	3	60 Hz

A-28359-1
REV. 01-19-00

SIEMENS
Water Technologies
Ames, IA
515-268-8400

ALUMINUM FORCED DRAFT AERATORS

Please refer to Siemens Water Technologies drawings: A–28359-1.

5 General Filter Aluminum Forced Draft Aerators designed to treat water at a design flow of 2240 gpm/unit. The basic shell dimensions of the Aerator are 12' sq x 15' side height. Each Aerator also includes the following features factory installed:

- 1/4" aluminum aerator housing shell and collector pan
- 1/4" fixed cover
- support legs with predrilled anchor bolt holes (anchor bolts not by Siemens Water Technologies)
- air inlet mounting flange
- two bolt-on media access ports on side
- aluminum distribution tray complete with velocity breaker box and aluminum air stacks
- target nozzles
- 1,440 cu. ft. high efficiency polypropylene gas exchange media with aluminum support system.
- 13" x 15" inspection port below the internals
- 18" dia. inspection manhole in cover
- 16" flanged top inlet connection
- 24" plain end bottom outlet connection
- internal effluent air seal
- air exhaust mounting flange

5 Forced draft non-overloading centrifugal type blower, factory assembled and sized to deliver 13,500 cfm @ 1" static pressure, including the following features:

- factory primed reinforced heavy steel blower housing (anchor bolts not by Siemens Water Technologies)
- dynamically balanced welded steel blower wheel
- anti-friction, self-aligning, grease packed, pillow block type bearings with grease and dirt seal
- 7 1/2 hp, 230/460 V, 3 ph, 60 Hz, open drip-proof drive motor
- adjustable V-belt drive 36" sq. units and larger
- weatherproof motor hood

5 Aluminum and stainless steel air inlet hood and screen. This item is shipped loose for field mounting by the installing contractor.

5 Aluminum blower-to-aerator discharge transition section. This item is shipped loose for field mounting by the installing contractor.

5 Aluminum and stainless steel air exhaust hood with moisture separator and screen. This item is shipped loose for field mounting by the installing contractor.

Note: Materials of construction are Type 3003 or 5052 aluminum plates with Type 6061 aluminum structural members. Assembly and mounting hardware is Type 18-8 stainless steel.

NOTE: Due to the aluminum (or stainless steel) alloy used, exposed surfaces may have a dull or uneven appearance, and water staining is possible.

Installation Notes:

1. It is recommended that a delay timer be used to keep the blower running for at least 60 seconds after the pump stops. This is to prevent water from running back into the blower during shutdown. Aerator controls and timers are not by Siemens Water Technologies.

2. Aerator influent flanged connection is not designed to support the weight of the influent piping. Alternate means of influent pipe support should be provided.

PERTINENT DATA – FORCED DRAFT AERATOR

Aerator

1.) Type: Forced Draft Aerator

2.) Application: VOC Removal

3.) Number of units: 5

4.) Normal Flow Rate: 2,240 GPM/UNIT

5.) Total Flow Rate: 11,200 GPM

6.) Nominal Size: 12' Square x 15' Side Height w/o legs

7.) Loading: 15.5 GPM/Sq.Ft. of Cross-Sectional Area

8.) Housing Material: Aluminum w/two media installation/removal ports

9.) Distributor Box: Aluminum with air stacks and target nozzles

10.) Depth of Internals: 10 Feet

11.) Type of Internal Fill: Jaeger Tri-Packs, size: 2" diameter

12.) Influent Pipe Size: 16" flanged

13.) Effluent Pipe Size: 24" plain end; Dresser or flexible coupling not included

14.) Air Exhaust: Standard #24 mesh hood with moisture separator

Blower

1.) Make: Peerless-Winsmith Inc.

2.) Nominal Capacity: 13,500 CFM @ 1" Static Pressure

3.) Motor: 7 1/2 hp, 230/460 Volts, 3 Ph, 60 Hz, TEFC

4.) Electrical Control: Motor starter is not by Siemens Water Technologies

5.) Standard blower screened air inlet hood

6.) Standard aluminum blower to aerator transition

7.) Remarks: Blower base is not by Siemens Water Technologies

Performance

1.) Predicted Ethyl Benzene Reduction: 95%

2.) Water Temperature: 60 °F

NOTE: Due to the aluminum alloy used, exposed surfaces may have a dull or uneven appearance, and water staining is possible.

JOB NAME	Red Hill Water Treatment				
JOB NO.	2008014	SHEET	1	OF	2
CALCULATED BY	HC	DATE	06/04/2009		
CHECKED BY		DATE			

Objective: Sizing GAC Contactors

Given:

Q = 16 mgd — Design Capacity

Assume:

Use 3 primary GAC contactors and 3 secondary GAC contactors (2 operating/1 stanby)

n	=	2	The number of phases
N1	=	2	The number of operating GAC contactors
N2	=	1	The number of standby GAC contactors

GAC Bed Parameters

EBCT	=	15 min	Empty bed contact time; 5 to 25 min *
HLR	=	5 gpm/ft^2	Hydraulic loading rate; 2 to 10 gpm/ft^2 *
	=	0.6684 $ft^3/m/ft^2$	
FB	=	D* 0.3 ft	Freeboard = 30% X GAC Bed Depth; to prevent GAC loss during backwash; 20 to 30% *

Backwash Parameters

BD	=	15 min	Backwash duration; 10 to 20 min *
BR	=	18 gpm/ft^2	Backwash rate; 15 to 20 gpm/ft^2 *

q	=	Q/N1	
	=	8 mgd	Design capacity of each contactor
	=	5552 gpm	

GAC Contactor Sizing

According to AWWA 1989, the empty bed contact time (EBCT) typically ranges from 5 to 25 min.

For min EBCT = 5 min, calculate critical GAC bed depth

D_{cr} = HRL x $EBCT_{min}$

= 3.34202 ft

For max EBCT = 25 min, calculate max GAC bed depth

D_{max} = HRL x $EBCT_{max}$

= 16.7101 ft

-> Design GAC bed depth (D) = **10** ft

-> EBCT = D/HRL = **14.96** min

A = q/HLR — Surface area of each contactor

= 1110.4 ft^2

Let L:W = 2:1 for each contactor

W = 23.5627

say **24** ft — Width of each contactor

L = **48** ft — Length of each contactor

Assume DW = 10 ft (water above GAC bed for gravity GAC contactors)

The GAC contactor height (H)

H = D + DW +FB

H = 23 ft

say **25** ft — Height of each contactor

->

The proposed GAC contactor dimensions: 48 ft (L) x 24 ft (W) x 25 ft (H)

Total volume of GAC required for the facility

V = L x W X D x 6

= **69,120** ft^3

On-site GAC Storage

On-site storage is required to supply carbons for at least two contactors

V1 = **23,040** ft^3 — Min GAC storage volume (2 contactors' volume)

Let L:W=1:1 for GAC storage structure

Assume

L = **30** ft — Length of GAC storage

->

W = **30** ft — Width of GAC storage

h = 25.6 ft

say **28** ft — Height of GAC storage including overhead

According to Calgon Carbon, the recommended type of GAC is F-400

F-400 density = 30 lb/cf

F-400 cost = 1.5 $/lb

Cost for GAC = $ 3,110,400

Cost for on-site GAC stored = $ 1,036,800

* Note: Design criteria range from "Organics Removal by Granular Activated Carbon", by AWWA 1989

** GAC apparent density from Calgon Carbon.

FILTRASORB® 400

Granular Activated Carbon for Municipal Specifications

CALGON
CALGON CARBON CORPORATION

Description

FILTRASORB® 400 is a granular activated carbon developed by Calgon Carbon Corporation for the removal of taste and odor compounds, disinfection by-product precursors, and other dissolved organic compounds from potable water. Although this product can be used for ground water applications, it was specifically developed for surface water applications with higher levels of background total organic carbon.

This activated carbon is made from selected grades of bituminous coal to produce a high activity, durable granular product capable of withstanding the abrasion associated with repeated backwashing, air scouring, and hydraulic transport. Activation is carefully controlled to produce a product with a significant volume of lower energy pores as measured by iodine number, while still maintaining a high trace capacity number for effective adsorption of a broad range of high and low molecular weight organic contaminants. The product is also formulated to comply with all the applicable provisions of the AWWA Standard for Granular Activated Carbon, edition B604-05, the stringent extractable metals requirements of ANSI/NSF Standard 61, and the Food Chemicals Codex.

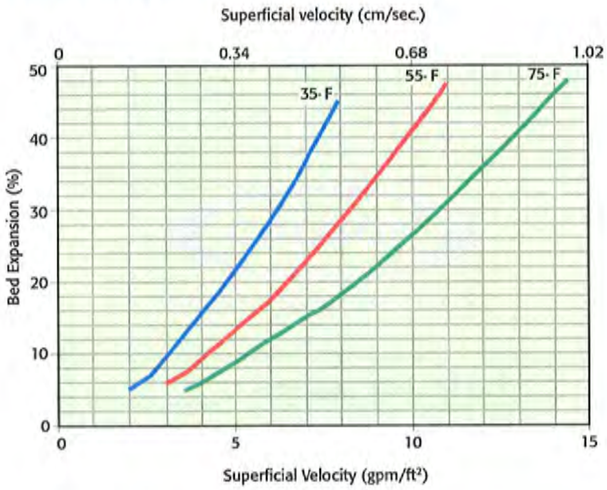
Specifications	Value
Iodine Number.	1000 mg/g (min)
Moisture by weight	2% (max)
Effective size	0.55 - 0.75 mm
Uniformity Coefficient	1.9 (max)
Abrasion No.	75 (min)
Trace Capacity Number	10 mg/cc (min)
Screen Size by weight, US Sieve Series	
On 12 mesh	5% (max)
Through 40 mesh	4% (max)

Typical Property	Value
Apparent Density	0.52 g/cc
Ash by weight	9%

Features	Benefits
Bituminous-based raw material	Provides higher hardness relative to other raw materials reducing the generation of fines and product losses during backwashing.
Coal is pulverized and reagglomerated with suitable binder	Pore structure provides a product with a significant volume of lower energy pores as measured by iodine number, while still maintaining a high trace capacity number. Wets readily, and does not float, thus minimizing loss during backwash operations. Creates optimal transport paths for faster adsorption.

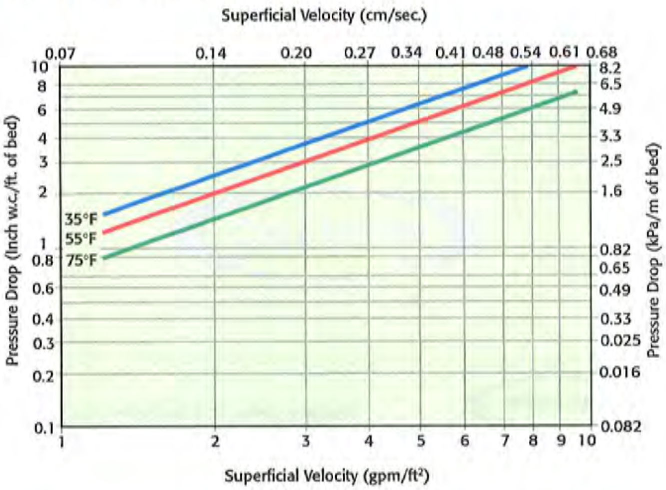
Bed Expansion

Based on backwashed and segregated bed



Pressure Drop

Based on backwashed and segregated bed



FILTRASORB® 400

Granular Activated Carbon for Municipal Specifications

CALGON CARBON CORPORATION

Applications

FILTRASORB® 400 activated carbon can be used to treat surface and groundwater sources for the production of drinking water. This product can be used as a complete replacement for sand and anthracite media. FILTRASORB® 400 activated carbon functions as a dual purpose media, providing both filtration and adsorption. FILTRASORB® has been used successfully in drinking water applications for over 40 years.

Design Considerations

As a replacement for existing filter media, conversion to FILTRASORB® 400 granular activated carbon imposes no major changes to a plant's normal filtration operations. Calgon Carbon Corporation can also provide complete modular adsorption systems as an add-on treatment stage if required.

Safety Message

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures for potentially low oxygen spaces should be followed, including all applicable Federal and State requirements.

CALGON CARBON CORPORATION

Making Water and Air Safer and Cleaner

Calgon Carbon Corporation
P.O. Box 717
Pittsburgh, PA USA 15230-0717
1-800-422-7266
Tel: 1-412-787-6700
Fx: 1-412-787-6713

Chemviron Carbon
European Operations of
Calgon Carbon Corporation
Zoning Industriel C de Feluy
B-7181 Feluy, Belgium
Tel: + 32 (0) 64 51 18 11
Fx: + 32 (0) 64 54 15 91

Calgon Carbon Asia PTE LTD
9 Temasek Boulevard
#08-01A Suntec Tower Two
Singapore 038989
Tel: + 65 6 221 3500
Fx: + 65 6 221 3554

Your local representative

Material Safety Data Sheet

U.S. Department of Labor
Occupational Safety and Health Administration
This form is consistent with ANSI standard for preparation of MSDS's in accordance with OSHA's Hazard Communication Standard, 29 CFR 1910.1200.

Product Type:	**FILTRASORB 400**		
Product Code:	2030	**Profile No:**	1
Effective Date:	**March 31, 2008**	**Supersedes:**	**XXXXX**

SECTION I - PRODUCT AND COMPANY INFORMATION

Company Identification (USA)	**Calgon Carbon Corporation** P.O. Box 717 Pittsburgh, PA 15230-0717	
Telephone Number(s)	Information	412-787-6700
	Emergency	412-787-6700
Company Identification (Europe)	**Chemviron Carbon** Zoning Industriel de Feluy B-7181 Feluy, Belgium	
Telephone Number(s)	Information	32 64 51 18 11
	Emergency	32 64 51 18 11
Date Prepared November 3, 2008	Signature of Preparer (optional)	

SECTION II – COMPOSITION /INFORMATION ON INGREDIENTS

Nonhazardous components are listed at 3% or greater; acute hazards are listed when present at 1% or greater and chronic hazards are listed when present at 0.01% or greater. This is not intended to be a complete compositional disclosure.

Ingredient / Component	**CAS No**	**% by Wt**
Activated Carbon (Coal based)	7440-44-0	100

SECTION III – HAZARD(S) IDENTIFICATION

Emergency Overview: Black particulate solid, pellet or powder. Contact may cause eye irritation. Dust may be slightly irritating to eyes and respiratory tract. Avoid generation of dust during handling.

CAUTION: Wet activated carbon removes oxygen from air causing a severe hazard to workers in enclosed or confined space. Before entering such an area, sampling and work procedures for low oxygen levels should be taken to ensure ample oxygen availability, observing all local, state and federal regulations

OSHA Regulatory Status	Not regulated		
HMIS Ratings (NFPA)	Health	0	4 = Extreme/Severe 3 = High/Serious 2 = Moderate 1 = Slight 0 = Minimum W = Water Reactive OX = Oxidizer
	Flammability	1	
	Reactivity	0	
	Special		
Protective Equipment	Safety glasses with side shields or goggles, gloves, long sleeve shirt or lab coat, long pants recommended.		
Health Effects	See Section IV		
Environmental Effects	See Section XII		

Section IV – First-Aid Measures

Route of exposure	
Eyes	Dust may cause mild irritation, possibly reddening.
Skin	Dust may cause mild irritation, possibly reddening.
Inhalation	Dust may cause mild irritation to the upper respiratory tract.
Ingestion	Dust may cause mild irritation to digestive track resulting in nausea or diarrhea.
Signs/Symptoms of Exposure	Dust may cause irritation and redness of eyes, irritation of skin and respiratory system.
Emergency and First Aid Procedures	For eye contact, immediately flush with copious amounts of water for at least 15 minutes, lifting both the upper and lower lids occasionally; seek medical attention. For skin contact, wash with soap and water; seek medical attention. For inhalation, Remove to fresh air and rest as needed; seek medical attention for any breathing difficulty. For ingestion, drink plenty of water; seek medical attention.
Medical Conditions Generally Aggravated by Exposure	People with pre-existing skin conditions or eye problems or impaired respiratory function may be more susceptible to the potential effects of the dust.

SECTION V – FIRE FIGHTING MEASURES

Suitable Extinguishing Media	Use an extinguishing media suitable for the surrounding fire.
Unsuitable Extinguishing Media	None known
Specific Hazards	As with most organic solids, fire is possible at elevated temperatures or by contact with an ignition source. Activated carbon is difficult to ignite and tends to burn slowly (smolder) without producing smoke or flame. Carbon monoxide and carbon dioxide gas may be generated if combusted. Contact with strong oxidizers such as ozone or liquid oxygen may cause rapid combustion.
Protective Equipment and Procedures	Wear NIOSH approved self-contained breathing apparatus suitable for the surrounding fire.

SECTION VI – ACCIDENTAL RELEASE MEASURES

Personal Precautions	Wear protective equipment, keep unnecessary personnel away, ventilate area of spill.
Environmental Precautions	The material is not soluble but can cause a particulate emission if discharged to waterways; therefore, dike all entrances to sewers and drains to avoid introducing the material into the waterways.
Containment & Clean-up	Dike all entrances to sewers and drains. Vacuum or shovel spilled material and place in closed container for disposal. Remove product to appropriate storage area until it can be properly disposed of in accordance with local, state and federal regulations. Avoid dust formation. See section XIII
Other information	NA

SECTION VII – HANDLING AND STORAGE

Handling	Avoid prolonged contact with eyes and skin. Keep away from ignition sources. Use in well ventilated areas. Protect containers from physical damage. Wash hands after handling.
Storage	Store in cool, dry, ventilated area and in closed containers. Keep away from oxidizers, heat or flames. Store away from ignition sources.

SECTION VIII – EXPOSURE CONTROLS/PERSONAL PROTECTION

Component	OSHA PEL	ACGIH TLV	Other limits
Activated Carbon	5 mg/M^3 Resp	5 mg/M^3 Resp	

Exposure Guidelines	Wet activated carbon removes oxygen from air posing a hazard to workers in enclosed or confined space. Before entering such an area, sample the air to assure sufficient oxygen supply. Use work procedures for low oxygen levels, observing all local, state and federal regulations.
Engineering Controls	No special ventilation requirements. Good general ventilation should be adequate. Mechanical ventilation is recommended for enclosed or confined spaces
Personal Protective Equipment	Use of NIOSH approved particulate filter is recommended if dust is generated in handling. The usual precautionary measures for handling chemicals should be followed, i.e. gloves, safety glasses w/side shields or goggles, long sleeve shirt or lab coat, dust respirator if dusty. Other protective clothing/equipment as appropriate.
General Hygiene	The usual precautionary measures for handling chemicals should be followed: i.e. Keep away from food and beverage; remove contaminated clothing immediately; wash hands before breaks or eating; avoid contact with eyes and skin.

SECTION IX – PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point	NA	**Melting Point**	NA
Vapor Pressure (mm Hg.)	0	**Evaporation Rate**	NA
Vapor Density (AIR = 1)	solid	**Flash Point**	NA
Specific Gravity	0.4 to 0.7	**UEL**	NA
		LEL	NA
Flammability Limits	Ignition Temperature > 220º C		
Odor	None		
Solubility in Water	Product is not soluble.		
Appearance	Black granular or powder material		

SECTION X – STABILITY AND REACTIVITY

STABILITY	**UNSTABLE**		**CONDITIONS TO AVOID:** None
	STABLE	**XX**	
HAZARDOUS REACTION	**MAY OCCUR**		**CONDITIONS TO AVOID:** None
	WILL NOT OCCUR	**XX**	
Caution: High concentrations of organics in air will cause temperature rise due to heat of adsorption. At very high concentration levels this may cause a bed fire. High concentrations of Ketones and Aldehydes may cause a bed temperature rise due to adsorption and oxidation.			
Incompatible Materials			Alkali Metals and Strong Oxidizers such as ozone, oxygen, permanganate, chlorine.
Hazardous Decomposition Products			Carbon monoxide and carbon dioxide gas may be generated during combustion of this material.

SECTION XI – Toxicological information

Acute Effects		
Toxicity Studies	Oral LD_{50}	Not Determined on the finished product.
	Dermal LD_{50}	Not Determined on the finished product.
Inhalation	See section IV	
Ingestion	See section IV	
Eye Irritation	See section IV	
Skin Irritation	See section IV	
Sensitization	Not Determined on the finished product.	
Target Organ (s) or System		Eyes, Skin and Upper Respiratory System
Signs and symptoms of Exposure		Irritation and redness of eyes, irritation of skin and respiratory system may result from exposure to carbon dust. See Sections III and IV
Chronic Effects		
Carcinogenicity	Not Determined on the finished product.	
Mutagenicity	Not Determined on the finished product.	
Reproductive Effects	Not Determined on the finished product.	
Developmental Factors	Not Determined on the finished product.	

SECTION XII – ECOLOGICAL INFORMATION

Ecotoxicity	Not Determined on the finished product.
Persistence/degradability	Not Determined on the finished product.
Bioaccumulation/Accumulation	Not Determined on the finished product.
Mobility in Environmental Media	Not Determined on the finished product.
Other Adverse Effects	Not Determined on the finished product.

SECTION XIII – DISPOSAL CONSIDERATIONS

Vacuum or shovel material into a closed container. Storage and disposal should be in accordance with applicable local, state and federal laws and regulations. Local regulations may be more stringent than state or federal requirements.

SECTION XIV – TRANSPORT INFORMATION

This information as presented below only applies to the material as shipped. The identification based on characteristic(s) or listing may not apply if the material has been used or otherwise contaminated. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste identification and disposal methods in compliance with applicable regulations.

Land	DOT Regulations	Proper Shipping Description	FILTRASORB 400 (Steam Activated Carbon)
	Canadian WHMIS	Hazard Class	NA See note below
		UN/NA	UN 1362
Water	IMO / IMDG	Proper Shipping Description:	FILTRASORB 400 (Steam Activated Carbon)
		Hazard Class	NA See note below
		UN/NA	UN 1362
Air	IACO / IATA	Proper Shipping Description	FILTRASORB 400 (Steam Activated Carbon)
		Hazard Class	NA See note below
		UN/NA	UN 1362
		Information reported for product/size: 0.5 Kg	

This product has been tested according to the *United Nations Transport of Dangerous Goods* test protocol for a “self-heating substance”. It has been specifically determined that this product does not meet the definition of a self heating substance or any other hazard class, and therefore is not a hazardous material. Please note that this information is applicable only for the Activated Carbon Product identified in this document.

SECTION XV – REGULATORY INFORMATION

<table>
<tr><td>SARA Title III 302</td><td colspan="2">Product is not subject to SARA Title III, section 302 regulation.</td></tr>
<tr><td>SARA Title III 313</td><td colspan="2">Product is not subject to SARA Title III, section 313 regulation.</td></tr>
<tr><td>TSCA</td><td colspan="2">Product is listed</td></tr>
<tr><td>California Proposition 65</td><td colspan="2">Product is not listed</td></tr>
<tr><td rowspan="2">Canadian classification</td><td>WHMIS</td><td>Product is listed.</td></tr>
<tr><td>DSL #</td><td>Product is listed.</td></tr>
<tr><td colspan="3">EEC Council Directives relating to the classification, packaging, and labeling of dangerous substances and preparations.</td></tr>
<tr><td>Risk and Safety Phrases</td><td colspan="2">R36: Irritating to the eyes,
R37: Irritating to the respiratory system,
R38: Irritating to the skin,</td></tr>
</table>

SECTION XVI – OTHER INFORMATION

<table>
<tr><td>Intended Use</td><td>The material is generally used for treatment of gases and liquids</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">The information contained in this document applies to this specific material as supplied. It may not be valid for this material if it is used in combination with any other materials. It is the user's responsibility to determine the suitability and completeness of this information for their particular use.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">While the information and recommendations set forth herein are believed to be accurate as of the date hereof, Calgon Carbon Corporation makes no warranty with respect to same and disclaims all liability for reliance there on.</td></tr>
</table>

References:

NA	not applicable

Legend:

ACGIH	- American Conference of Governmental Industrial Hygienists
ANSI	- American National Standards Institute
ATSDR	- Agency for Toxic Substances and Disease Registry
C	- Ceiling (limit value)
CAS #	- Chemical Abstracts Service Registry Number
CERCLA	- Comprehensive Environmental Response, Compensation, and Liability Act
CEPA	- Canadian Environmental Protection Act
CFR	- Code of Federal Regulations
DOT	- Department of Transportation
DSL	- Domestic Substances List
EINECS	- European Inventory of Existing Commercial Chemical Substances
ERAP	- Emergency Response Assistance Plan
IATA	- International Air Transportation Association
IARC	- International Agency for Research on Cancer
ICAO	- International Civil Aviation Organization
IDLH	- Immediately Dangerous to Life and Health
IMO	- International Maritime Organization
IMDG	- International Maritime Dangerous Goods
LC_{50}	- The concentration of material in air expected to kill 50% of a group of test animals
LD_{50}	- Lethal Dose expected to kill 50% of a group of test animals
NFPA	- National Fire Protection Association
NIOSH	- National Institute for Occupational Safety and Health
NTP	- National Toxicology Program
OSHA	- Occupational Safety and Health Association
PEL	- Permissible Exposure Limit
RCRA	- Resource conservation and Recovery Act
RQ	- Reportable Quantity
SARA	- Superfund Amendments and Reauthorization Act
STEL	- Short Term Exposure Limit
TDG	- Transportation of Dangerous Goods Act/Regulation
TLV	- Threshold Limit Value
TSCA	- Toxic Substances Control Act
TWA	- Time Weighted Average
WHMIS	- Workplace Hazardous Material Information System

* * * END OF MATERIAL SAFETY DATA SHEET * * *

Westates® coconut shell based granular activated carbon - AquaCarb® 830C, 1230C and 1230AWC (12 x 30 products formerly CC-602 and CC-602AW)

For use in Potable Water, Wastewater and Process Water applications

Description

AquaCarb® 830C, 1230C and 1230AWC carbons are high activity coconut shell based granular activated carbons. These hard, attrition resistant high surface area carbons are designed to remove difficult to adsorb organics from potable, waste and process water. They are especially effective for adsorbing chlorine, disinfection by-products, TCE, PCE, MTBE and other trace level organics. AquaCarb® 1230AWC carbon is acid washed yielding a very low ash content, pH neutral carbon that is ideally suited for use in potable water and high purity water systems for the microelectronics and other industries.

Applications

Cost effective AquaCarb® activated carbons developed by Siemens have been demonstrated to provide superior performance in an extensive array of liquid phase treatment applications. AquaCarb® activated carbons are available for:

- Removal of trace organic contaminants
- Pesticide removal
- MTBE removal
- Disinfection by-product (DBP) removal
- Drinking water treatment
- Industrial process water treatment
- High purity water applications
- Home water filtration systems

Quality Control

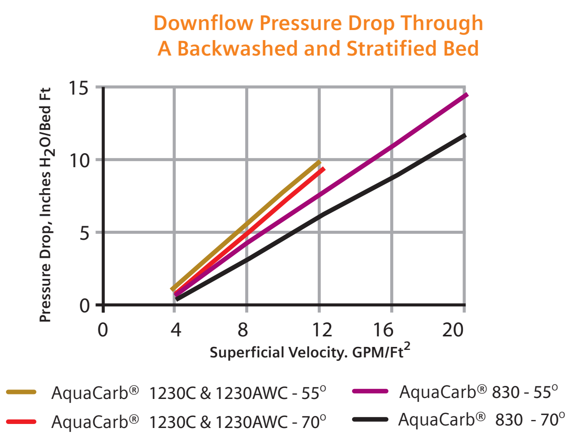
AquaCarb® activated carbons are extensively quality checked at our State of California certified environmental and carbon testing laboratory located in Los Angeles, CA. Siemens' laboratory is fully equipped to provide complete quality control analyses using ASTM standard test methods in order to assure the consistent quality of all Westates® carbons.

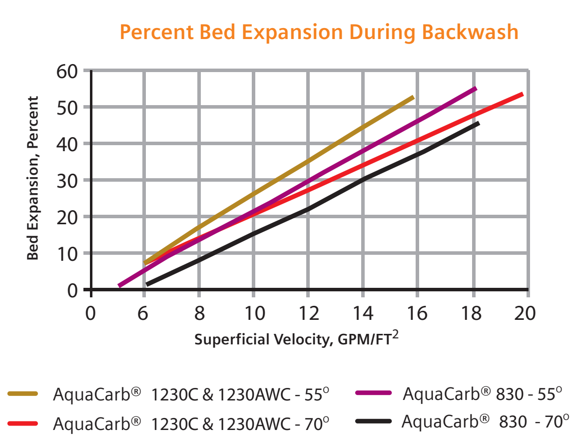
Our technical staff offers hands-on guidance in selecting the most appropriate system, operating conditions and carbon to meet your needs. For more information, contact your nearest Siemens representative.

Features and Benefits:

- ANSI/NSF Standard 61 classified for use in potable water applications
- Fully conforms to physical, performance and leachability requirements established by the current ANSI/AWWA B604 (which includes the Food Chemical Codex requirements)
- A detailed quality assurance program guarantees consistent quality from lot to lot and shipment to shipment

Typical Properties			
Parameter	AquaCarb® 1230C	AquaCarb® 1230AWC	AquaCarb® 830C
Carbon Type	Coconut Shell	Coconut Shell	Coconut Shell
Mesh Size, U.S. Sieve	12 x 30	12 x 30	8 x 30
Effective Size, mm	0.6 - 0.85	0.6 - 0.85	0.8 - 1.1
Uniformity Coefficient	2.0	2.0	2.1
Iodine No., mg I_2/g	1100	1100	900
Hardness No., Wt. %	95	95	95
Abrasion No., Wt. %	85	85	85
Apparent Density, g/cc	0.46 - 0.52	0.45 - 0.52	0.46 - 0.52
Water Soluble Ash, Wt. %	2	0.2	2
Contact pH	9 - 10	6.5 - 8	9 - 10





Safety Note: Under certain conditions, some compounds may oxidize, decompose or polymerize in the presence of activated carbon causing a carbon bed temperature rise that is sufficient to cause ignition. Particular care must be exercised when compounds that have a peroxide-forming tendency are being adsorbed. In addition the adsorption of VOCs will lead to the generation of heat within a carbon bed. These heats of reaction and adsorption need to be properly dissipated in order to fully assure the safe operation of the bed.

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may exist in closed vessels or poorly ventilated storage areas. Workers should follow all applicable state and federal safety guidelines for entering oxygen depleted areas.

All information presented herein is believed reliable and in accordance with accepted engineering practices. Siemens makes no warranties as to the completeness of this information. Users are responsible for evaluating individual product suitability for specific applications. Siemens assumes no liability whatsoever for any special, indirect or consequential damages arising from the sale, resale or misuse of its products.

Siemens
Water Technologies
2430 Rose Place
Roseville, MN 55113
800.525.0658 phone

WS-AQ12dr-DS-0308
Subject to change without prior notice.

HDR | Hawaii Pacific Engineers, Inc.

JOB NAME	Red Hill Water Treatment				
JOB NO.	2008014	SHEET	1	OF	3
CALCULATED BY	HC	DATE	07/01/2009		
CHECKED BY		DATE			

Objectives: To estimate GAC bed life based on the MAICs

Chemical	CAS Number	Solubility[1] 20-25°C mg/L	HDOH[2] EALs mg/L	EPA[3] MCL mg/L	Est. GAC Infl. Conc. mg/L	Freundlich[4] Coeff K $(mg/g)(L/mg)^{1/n}$	Freundlich[4] Coeff 1/n	Freundlich[5] Coeff q_e mg/g	Carbon[6] Usage Rate CUR g/L	Carbon[7] Bed Life Z L H_2O/L GAC	Carbon[8] Bed Life Time years
Petroleum											
* TPH (middle distillates)	-	-	1.00E-01	-	5.00E-01	-	-	-	-	-	-
TPH (gasolines)	-	-	1.00E-01	-	5.00E-01	-	-	-	-	-	-
PAH (Semi-Volatile)											
Acenaphthene	83-32-9	3.90E+00	2.00E-02	-	1.00E-01	190	0.36	46.46	1.72E-03	3.02E+05	18
Acenaphthylene	208-96-8	1.61E+01	2.40E-01	-	1.20E+00	115	0.37	67.82	1.42E-02	3.67E+04	2
Anthracene	120-12-7	4.34E-02	7.30E-04	-	3.65E-03	376	0.70	2.40	1.22E-03	4.27E+05	25
Benzo(a)Anthracene	56-55-3	9.40E-03	2.70E-05	-	1.35E-04	-	-	-	-	-	-
Benzo(a)Pyrene	50-32-8	1.62E-03	1.40E-05	2.00E-04	7.00E-05	34	0.44	0.25	2.25E-04	2.31E+06	136
Benzo(b)Fluoranthene	205-99-2	1.50E-03	9.20E-05	-	4.60E-04	181	0.57	0.91	4.06E-04	1.28E+06	76
Benzo(g,h,i)Perylene	191-24-2	2.60E-04	1.00E-04	-	5.00E-04	11	0.37	0.36	1.10E-03	4.74E+05	28
Benzo(k)Fluoranthene	207-08-9	8.00E-04	4.00E-04	-	2.00E-03	181	0.57	2.09	7.64E-04	6.80E+05	40
Chrysene	218-01-9	2.00E-03	3.50E-04	-	1.75E-03	-	-	-	-	-	-
Dibenzo(a,h)Anthtracene	53-70-3	2.49E-03	9.20E-06	-	4.60E-05	69	0.75	0.01	3.19E-03	1.63E+05	10
Fluoranthene	206-44-0	2.60E-01	4.00E-02	-	2.00E-01	664	0.61	93.20	1.72E-03	3.03E+05	18
Fluorene	86-73-7	1.69E+00	2.40E-01	-	1.20E+00	330	0.28	221.30	4.34E-03	1.20E+05	7
Indeno(1,2,3-cd)Pyrene	348085-46-1	1.90E-04	9.20E-05	-	4.60E-04	-	-	-	-	-	-
* Methylnaphthalene (total 1- & 2-)	1321-94-4	2.50E+01	-	-	-	-	-	-	-	-	-
* Methylnaphthalene, 1-	90-12-0	2.58E+01	4.70E-03	-	2.35E-02	-	-	-	-	-	-
* Methylnaphthalene, 2-	91-57-6	2.46E+01	1.00E-02	-	5.00E-02	-	-	-	-	-	-
* Naphthalene	75-34-3	3.10E+01	1.70E-02	-	8.50E-02	132	0.42	23.84	2.85E-03	1.82E+05	11
Phenanthrene	85-01-8	1.15E+00	7.70E-03	-	3.85E-02	215	0.44	25.26	1.22E-03	4.27E+05	25
Pyrene	129-00-0	1.35E-01	2.00E-03	-	1.00E-02	-	-	-	-	-	-
VOC											
Benzene	71-43-2	1.79E+03	5.00E-03	5.00E-03	5.00E-03	1	1.60	0.00	n/a	n/a	n/a
Bromomethane	74-83-9	1.52E+04	8.70E-03	-	4.35E-02	-	-	-	-	-	-
Ethylbenzene	100-41-4	1.69E+02	3.00E-02	7.00E-01	3.00E-02	53	0.79	3.32	n/a	n/a	n/a
Methyl Tert Butyl Ether	1634-04-4	5.10E+04	5.00E-03	-	5.00E-03	-	-	-	n/a	n/a	n/a
m-Xylene	108-38-3	1.61E+02	-	-	-	230	0.75	-	-	-	-
* Naphthalene	91-20-3	3.10E+01	1.70E-02	-	8.50E-02	132	0.42	23.84	2.85E-03	1.82E+05	11
o-Xylene	95-47-6	1.78E+02	-	-	-	174	0.47	-	-	-	-
p-Cymene	99-87-6	2.34E+01	-	-	-	-	-	-	-	-	-
Toluene	108-88-3	5.26E+02	4.00E-02	1.00E+00	4.00E-02	26	0.44	6.31	n/a	n/a	n/a
Trichlorobenzene, 1,2,4-	120-82-1	4.90E+01	7.00E-02	7.00E-02	3.50E-01	157	0.31	68.85	4.07E-03	1.28E+05	8
Trichloroethylene	79-01-6	1.28E+03	5.00E-03	5.00E-03	5.00E-03	2.80E+01	6.20E-01	1.05E+00	n/a	n/a	n/a
Xylenes	1330-20-7	1.06E+02	2.00E-02	1.00E+01	2.00E-02	-	-	-	n/a	n/a	n/a

1) Estimated GAC bed life based on single contaminants : 1.42E-02 g/L Acenaphthylene

Given design capacity Q = 16 mgd = 6.06E+07 L/d
Given 6 GAC contactors: three primary contactors (two operating/one standby) and three secondary contactors (two operating/one standby)
GAC bed dimensions: 24 (W) x 48 (L) x 10 (D)
GAC bed volume = 46080 ft3 = 1.30E+06 L GAC
Given GAC density = 1 g/cc = 14724.76 g/ft3

Estimated GAC bed life = 791 days = 2.20 years

---

2) Estimated GAC CUR based on the all contaminants : 3.98E-02 g/L

Given design capacity Q = 16 mgd = 6.06E+07 L/d
Given 6 GAC contactors: three primary contactors (two operating/one standby) and three secondary contactors (two operating/one standby)
GAC bed dimensions: 24 (W) x 48 (L) x 10 (D)
GAC bed volume = 46080 ft3 = 1.30E+06 L GAC
Given GAC density = 0.52 g/cc = 1.47E+04 g/ft3

Estimated GAC bed life = 281 days = 9.38 months

Note Estimated GAC CUR based on the all contaminants : 3.98E-02 g/L
*
1 Given design capacity Q = 16 mgd = 6.06E+07 L/d
2 Given 6 GAC contactors: three primary contactors (two operating/one standby) and three secondary contactors (two operating/one standby)
3 GAC bed dimensions: (W) x 48 (L) x 10 (D)
4 GAC bed volume = 46080 ft3 = 1.30E+06 L GAC
5 Given GAC density = 0.52 g/cc = 1.47E+04 g/ft3

Estimated GAC bed life = 281.2917359 days = 9.38E+00 months
K = Freundlich adsorption coefficient, (mg/g)(L/mg)1/n
n = empirical coefficient, 1/n is the function of the strength of adsorption
Ref: Shun Dar Lin, Water and Wastewater Calculations Manual, McGraw Hill, 2007

JOB NAME	Red Hill Water Treatment				
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6 The carbon usage rate (CUR) CUR (g/L) = (C0-C1)/(qe)0 where

CUR = carbon usage rate, g/L

(qe)0 = mass absorbed when Ce = C0 (when carbon is saturated), mg/g of GAC

C0 = influent concentration, mg/L = MAIC

C1 = average effluent concentration, mg/L = HDOH EAL

Ref: Shun Dar Lin, Water and Wastewater Calculations Manual, McGraw Hill, 2007

7 The carbon bed life, L H2O/L GAC Z = (qe)0 x ρ / (C0-C1)

Z = bed life, L H2O/L GAC

(qe)o = mass absorbed when Ce = C0, mg/g of GAC

ρ = apparent density of GAC, g/L = 0.52 g/cc (Calgon Carbon) = 520 g/L

C0 = influent concentration, mg/L = MAIC

C1 = average effluent concentration, mg/L = HDOH EAL

Ref: Samuel Denton Faust and Osman M. Aly, Chemistry of Water Treatment, CRC, 1998.

8 Carbon bed life time (days) = VZ/Q where

Z = bed life, L H2O/L GAC

V = GAC volume in contactor, L; V = 46080 ft3 = 1.30E+06 L

Q = design capacity, L/d; Q =16mgd = 6.06E+07 L/d

9 Equilibrium model time = (qe/C0) WT/Q

(qe)0 = mass absorbed when Ce = C0 (when carbon is saturated), mg/g of GAC

C0 = influent concentration, mg/L

WT = carbon weight, g; WT = V x ρ = 1382400 lbs = 6.27E+08 g

where V = 24x48x10x4 = 46080 ft3

ρ = 30 lb/ft3 (F-400 Calgon Carbon)

Q = design capacity, L/d; Q =16mgd= 6.06E+07 L/d

Objective: Sizing Pre-engineered GAC contactors

Given:

Q	=	16 mgd	Design Capacity
	=	1485.44 ft^3/min	
	=	11104 gpm	

GAC bed parameters

EBCT	=	15 min	Empty bed contact time; 5~25 min *
SLR	=	5 gpm/ft^2	Surface loading rate; 2~10 gpm/ft^2 *

Model 10

n	=	2	Each model 10 has two absorbers **
D	=	10 ft	Absorber diameter **
Each absorber contain		20,000 lbs GAC	**
Model unit price =		$ 220,000 /each	**

Type F-400 GAC properties

density	=	30 lb/ft^3	**
cost	=	1.5 $/lb	**

* AWWA, "Organic Removal by Granular Activated Carbon", 1989

** Calgon Carbon, Inc

Calculation based on EBCT

Volume of GAC required = Q x EBCT = 22282 ft^3

Quantity of GAC required = 668,449.20 lbs

GAC system recommended - Model 10

Absorber surface area (A) = 78.54 ft^2

Total number of absorber required = GAC quantity required/ GAC quantity per absorber

= 33 say 34 absorbers = 17 Model 10

Calculation based on SLR

Total GAC surface area required = Q / SLR = 2221 ft^2

GAC system recommended - Model 10

Absorber surface area (A) = 78.54 ft^2

Total number of absorber required

= 28 say 29 absorbers = 15 Model 10

JOB NAME	Red Hill Water Treatment				
JOB NO.	2008014	SHEET	2	OF	2
CALCULATED BY	HC	DATE	06/04/2009		
CHECKED BY		DATE			

Cost Estimation:

To be conservative and provide redundency, use 20 Model 10

GAC system recommended - Model 10 : 20 units

Cost of equipment = $ 4,400,000
Quantity of carbon = 800,000 lbs
Cost of carbon = $ 1,200,000

On-site GAC Storage:

Additional carbon storage to provide GAC for 5 systems
Quantity of onsite carbon = 200,000 lbs
= 6,667 ft^3
Cost of onsite carbon = $ 300,000

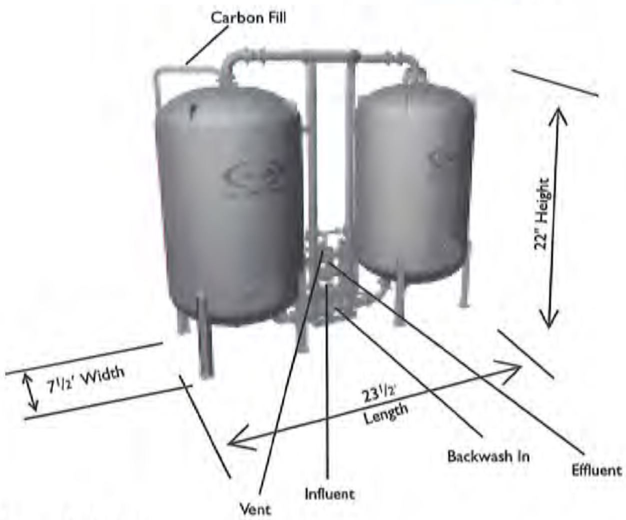
Let L:W=1:1 for GAC storage structure
Assume

L	=	**20**	ft	Length of GAC storage
->				
W	=	**20**	ft	Width of GAC storage
h	=	16.67	ft	
	say	**20**	ft	Height of GAC storage including overhead

Usage rate of	112,000	lbs/day
Cost per day =	168,000	$/day

MODEL 10

Modular Carbon Adsorption System



Description

The Calgon Carbon MODEL 10 is an adsorption system designed for the removal of dissolved organic contaminants from liquids using granular activated carbon. The modular design concept allows selection of options or alternate materials to best meet the requirements of the site and treatment application.

The MODEL 10 system is delivered as two adsorbers and a compact center piping network requiring only minimal field assembly and site connections. An optional mounting skid is available to facilitate installation. The pre-engineered MODEL 10 design assures that all adsorption system functions can be performed with the provided equipment.

The process piping network for the MODEL 10 accommodates operation of the adsorbers in parallel or series (with either adsorber placed in first stage). The piping can also isolate either adsorber from the flow. This permits carbon exchange or backwash operations to be performed on one adsorber without interrupting treatment.

The unique internal cone under-drain design provides for the efficient collection of treated water and the distribution of backwash water. The internal cone also insures efficient and complete discharge of spent carbon from the adsorber.

The MODEL 10 system is designed for use with Calgon Carbon's closed loop carbon exchange service. Using specially designed trailers, spent carbon is removed from the adsorbers and returned to Calgon Carbon for reactivation. The trailers also recharge the adsorbers with fresh activated carbon.

System Specifications

Carbon Adsorbers

- Carbon steel ASME code pressure vessels
- Internal vinyl ester lining (nominal 35 mil) where GAC contacts steel for potable water and most liquid applications
- Polypropylene slotted nozzles for water collection and backwash distribution

Standard Adsorption System Piping

- Schedule 40 carbon steel process piping with cast iron fittings
- Full bore stainless steel ball valves for GAC fill and discharge
- PPL lined steel pipe for GAC discharge
- Cast iron butterfly valves for process piping

System External Coating

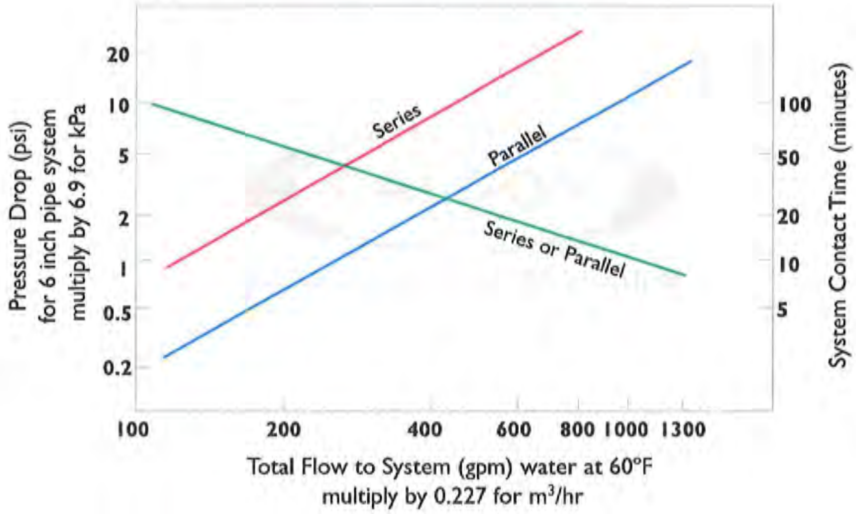
- Epoxy mastic paint system

Available Options

- Unifying system skid
- In-bed water sample collection probes

MODEL 10

Modular Carbon Adsorption System



Dimensions and Field Conditions

Adsorber Vessel Diameter	10 ft. (3,050 mm)
Process Pipe	6 in. or 8 in.
Process Pipe Connection	125# ANSI flange
Utility Water Connection	3/4 in. hose connection
Utility Air Connection	3/4 in. hose connection
Carbon Hose Connection	4 in. Kamlock type
Carbon Dry Fill	Top 8″ nozzle
Backwash Connections	6 in. or 8 in. flange
Drain/vent Connection	6 in. or 8 in. flange
Adsorber Maintenance Access	20 in. round flanged man-way, 14 in. x 18 in. man-way below cone
Adsorber Shipping Weight	18,500 lbs. empty (8,400 kg)
System Operating Weight	215,000 lbs. (97,610 kg)

Operating Conditions

Carbon per Adsorber	20,000 lbs. (9,080 kg)
Pressure Rating	125 psig (862 kPa)
Pressure Relief	Graphite rupture disk (94 psig)
Vacuum Rating	14 psig
Temperature Rating	150°F maximum (65°C)
Backwash Rate	Typical 1,000 gpm (30% expansion)
Carbon Transfer	Air pressure slurry transfer
Utility Air	100 scfm at 30 psig (reduce to 15 psig for trailer)
Utility Water	100 gpm at 30 psig
Freeze Protection	None provided; enclosure or protection recommended

Safety Message

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures for potentially low oxygen spaces should be followed, including all applicable Federal and State requirements.

Visit our website at **www.calgoncarbon.com**

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Chemviron Carbon

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Fx: + 32 (0) 64 54 15 91

Your local office

ES-EB1025-0604

SIEMENS WATER TECHNOLOGIES
P.O. Box 898
Brush Prairie, WA 98606

Telephone: (360) 326-8523 Facsimile: (866) 895-0114

Activated Carbon, Filtration Systems, Change-out Services, Spent Carbon Disposal & Reactivation

BUDGETARY QUOTE FORM

DATE	:	08-12-09
TO	:	Wendy Chen
COMPANY	:	HDR
FROM	:	Mike Tallering
SUBJECT	:	Red Hills Water Treatment System
PAGES	:	2 (Including Cover)

Wendy,

Per your request, please see the following budgetary pricing on GAC filter system.

Liquid Phase GAC Treatment System

Option #1

(12) HP1020 Dual Bed GAC Filter System@ $250,000/System $3,000,000

- As per attached specification sheet
- ASME Code Stamped vessels
- Includes 20,000 pounds of AC830C virgin coconut GAC per filter
- Includes piping rack & manifold
- Available 12-16 weeks ARO

Option #2

(8) HP1230 Dual Bed GAC Filter System@ $350,000/System $2,800,000

- As per attached specification sheet
- ASME Code Stamped vessels
- Includes 30,000 pounds of AC830C virgin coconut GAC per filter
- Includes piping rack & manifold
- Available 12-16 weeks ARO

Mobilization, Delivery, Off-Loading & GAC Loading

(1) Mobilization, Delivery, Off-Loading & GAC Loading $250,000

- Includes offloading vessels on-site
- Includes carbon loading on-site
- Assumes site access by crane and 48’ flat bed trucks

All pricing is budgetary. Pricing does not include any taxes, duties or applicable fees.

Thank you for the opportunity to provide pricing to you on your activated carbon needs. Please feel free to contact me with any questions or comments that you may have. You can reach me at 360-326-8523 or via email at mike.tallering@siemens.com.

Regards,

Mike Tallering
Senior Sales Engineer
Environmental Services – Pacific Northwest Region
SIEMENS **Water Technologies Corp.**
Tel: (360) 326-8523
Mobile: (503) 539-8835
Fax: (866) 895-0114
mike.tallering@siemens.com
www.siemens.com/water

HP® Series Liquid Phase Adsorption Systems (ASME code)

Applications

The HP® Series Adsorption Systems are designed to remove dissolved organic contaminants from water. These systems are cost effectively used in applications including:

- Groundwater remediation
- Wastewater filtration
- Tank rinse water treatment
- Pilot testing
- Underground storage tank clean up
- Leachate treatment
- Dechlorination
- Spill cleanup
- Food grade
- Drinking water

Installation, Startup and Operation

The HP® 810, HP® 1020 and HP® 1220 systems are shipped as separate components—two adsorbers and a piping skid module. The piping module allows the adsorbers to operate in series or parallel configurations. The systems require minimal field assembly and site connections.

Siemens can provide a total service package that includes utilizing OSHA trained personnel providing on-site carbon changeouts, packaging and transportation of spent carbon for recycling at our RCRA permitted reactivation facilities, where the contaminants are thermally destroyed.

We can provide instructions on sampling the spent carbon and completion of our spent carbon profile form. Spent carbon acceptance testing can be performed at our certified laboratory.

When requested, a certificate of reactivation will be issued.

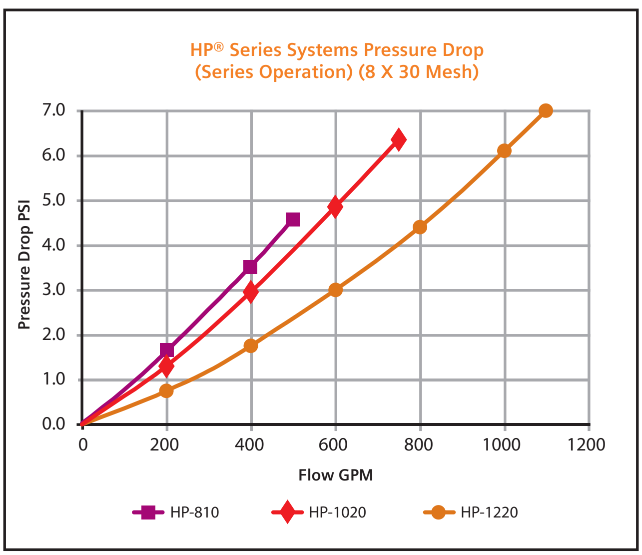
Benefits and Design Features:

- ASME code section VIII (stamped), carbon steel vessel.
- SSPC-SP5 surface preparation, NSF 6-approved Plasite vinyl ester lining; rust preventative epoxy/urethane exterior.
- Uniform, continuous internal lining flange to flange (HP® 1020/1220 Systems).
- Proprietary vertical 316 stainless steel externally removable septa nozzles (HP® 1020/1220 Systems) allows maintenance of underdrain without vessel entry.
- Modular design for easy handling and installation.
- Internal spray nozzle ensures complete removal of all spent carbon.
- Schedule 40 carbon steel pipe, supplied with cast iron gear/wheel operated butterfly valves with EPDM seats.
- Carbon slurry piping made from schedule 10 304 stainless steel.
- In-bed water sample collection ports —25-50-75% bed depths.
- Top and side manway allows for easy internal inspection.

Specifications/Typical Properties			
	HP® 810SYS	HP® 1020SYS	HP® 1220SYS
Dimensions (each adsorber - dia. x sidewall height)	96″ x 84″	120″ x 96″	144″ x 60″
Overall Height	15′ 2″	17′ 10″	15′ 10″
System Length	22′ 8″	26′	28' 10″
System Width	10′	12′	13′ 2″
Process Piping	6″	8″	8″
Flanged Inlet/Outlet (150# ANSI)	6″	8″	8″
Carbon Fill/Discharge	4″	4″	4″
Flanged Backwash/Vent	6″	8″	8″
Manway (dia., side shell location)	20″	20″	20″
Manway (top)	14″ x 18″	14″ x 18″	14″ x 18″
Utility Water/Air (hose connection)1	2″	2″	2″
Interior Coating	Vinyl Ester	Vinyl Ester	Vinyl Ester
Exterior Coating	Urethane	Urethane	Urethane
Empty System Weight (lbs.)	15,500	38,500	42,000
Carbon Weight/Vessel (lbs.)	10,000	20,000	20,000
Operating Weight (lbs.)	85,000	170,000	185,000
Design Pressure (PSIG) @ 140°F	125	125	125
Max. Flow (GPM) Series/Parallel	500/1,000	750/1,500	1,100/2,200
Backwash Rate (GPM) (8 x 30 mesh @ 55°F)	450	710	1,000

(1) Kamlock type

For detailed specifications or dimensional information or drawings, contact your local Siemens sales representative.



Safety Note: Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may exist in closed vessels or poorly ventilated storage areas. Workers should follow all applicable state and federal safety guidelines for entering oxygen depleted areas.

Siemens makes no warranties as to completeness of information. Users are responsible for evaluating individual product suitability for specific applications. Siemens assumes no liability whatsoever for any special, indirect or consequential damages arising from the sale, resale or misuse of its products. All information presented herein is believed reliable and in accordance with accepted engineering practice.

Siemens
Water Technologies
2430 Rose Place
Roseville, MN 55113
800.525.0658 phone

WS-HPdr-DS-0509
Subject to change without prior notice.

Siemens Water Technologies Environmental Services
11711 Reading Road Telephone (530) 527-2664
Red Bluff, CA 96080 Facsimile (530) 527-8724

HP1020S-125-SYS

SYSTEM SPECIFICATION SUMMARY

HP1020S Liquid Phase Adsorption Systems are designed to treat a wide range of contaminated process streams. All piping and valves are configured for series, parallel, or vessel isolation flows. System includes GAC inlet and outlet piping, and backwash capabilities. The system consists of two (2) adsorbers, with all piping, valves, and gauges assembled for ease of operation. Each adsorber is equipped with an underdrain capable of a maximum flow rate of 750 GPM.

EACH VESSEL:

Vessel Diameter .... 120”
Side Shell Height .... 96”
Overall Height (Approx.) .... …17’-10”
Maximum Working Pressure.. 125 psi @ 150 °F
Manway:
Flanged at side shell……………………………………..……… … .. 20”
Elliptical type at head……………………….…………………… 14” x 18”
Vessel Volume .... 6650 gal.
Carbon Capacity ....20,000 lbs.
Carbon Bed Volume-Typical ....714 Ft^3
Maximum Flow Rate ....1500 GPM Parallel, 750 GPM Series
Empty Bed Contact Time .... 7 min/vessel @ 750 GPM
Design Criteria .... ASME
Code Stamping .... YES
Material .... Carbon Steel
Supports .... Legs and Baseplates (2 vessels)
Lifting ....Lifting Lugs
Seismic ....Zone 4
Interior Surface Prep.. SSPC-SP5
Interior Surface Coating..Plasite 4110 35 mil dft min
Exterior Surface Primer .... Epoxy 3 mil min dft
Exterior Surface Coating..Urethane 3mil min dft
Standard Color..Desert Sand (#9225)

UNDERDRAINS:

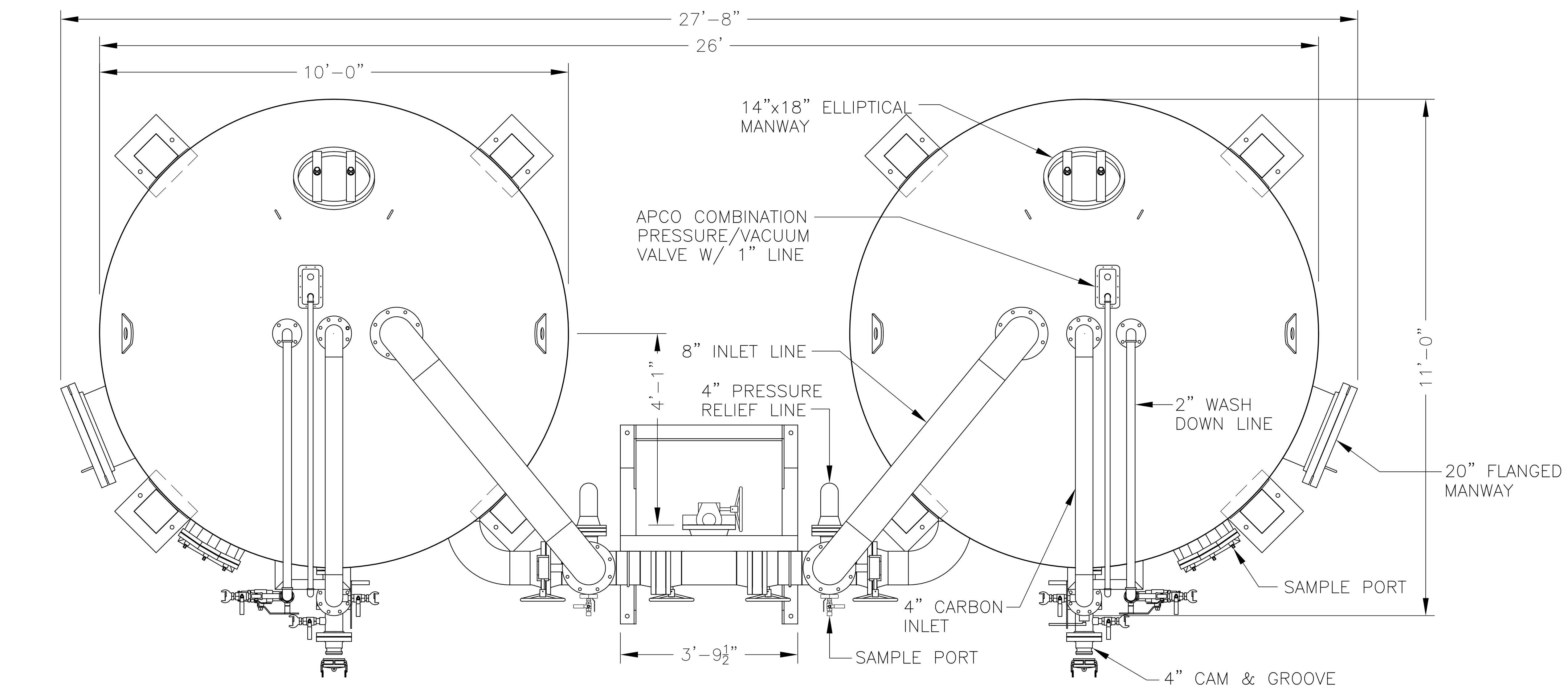
External Ring Header ....8” Sched 40 Carbon Steel
Screens....................... 8 ea 316L Stainless Steel V-Wire Screens 4 ½” dia x 10”

VALVE ASSEMBLY AND PIPING:

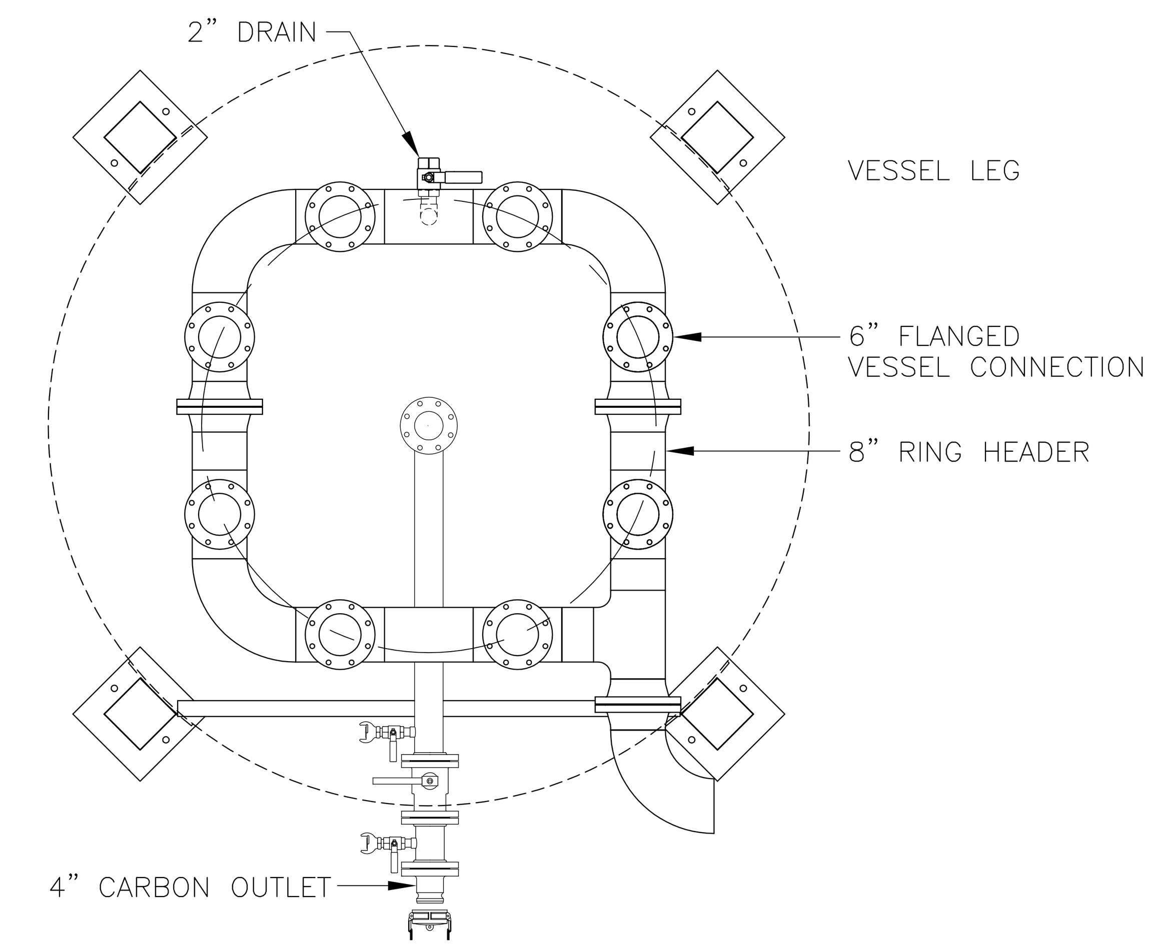
Piping:
Process Piping ....8” Schedule 40 Carbon Steel
GAC Transfer Piping ....4” Sch 10 304L Stainless Steel
Valves:
Process ....8” Butterfly, Cast Iron Body w/SS Disk, Gear Operator
GAC Transfer.................4” Fanged 316 Stainless Steel Full Port Ball Valve
Vent/Wash ....2” Bronze Ball Valve
Sample Ports (3) ....1/2” Bronze Ball Valve

SYSTEM WEIGHT:

System Shipping weight.. 38,500 lb
Carbon Weight two vessels .... 40,000 lb
System Operating Weight .... 170,000 lb



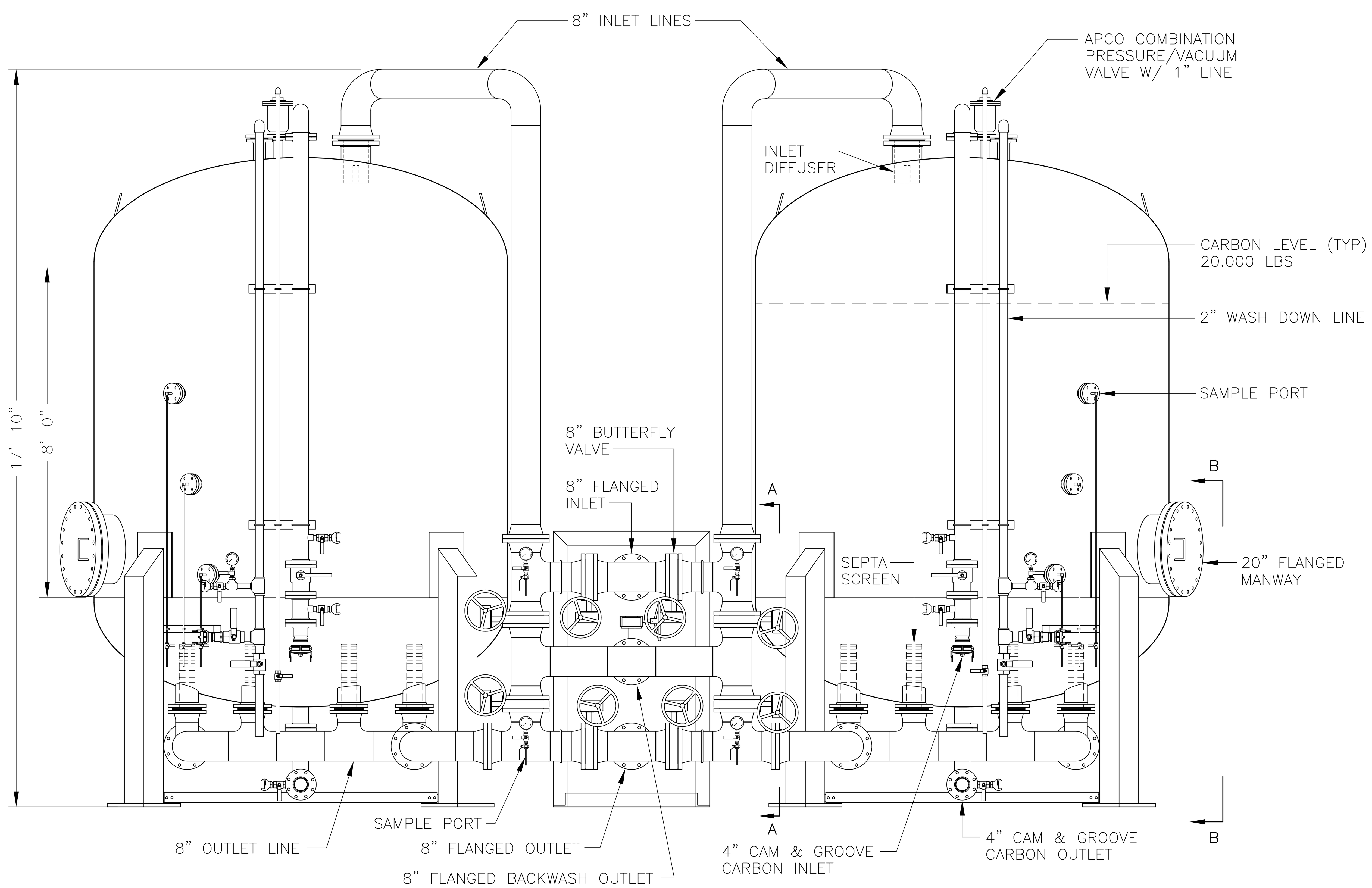
PLAN VIEW



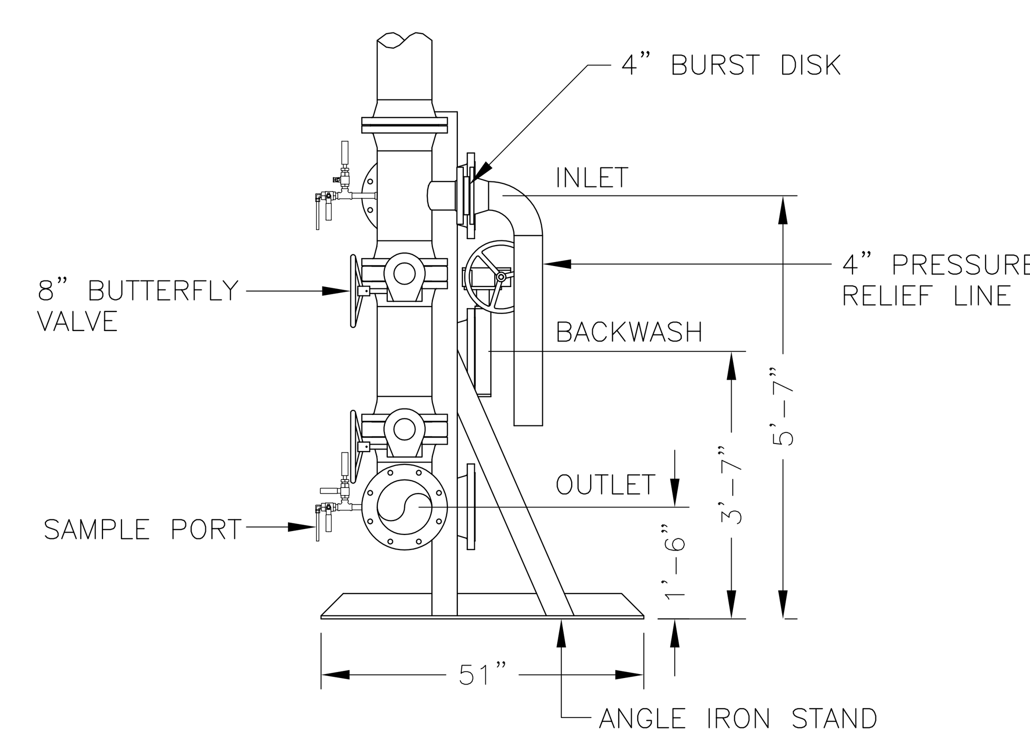
RING HEADER DETAIL

NOTES:

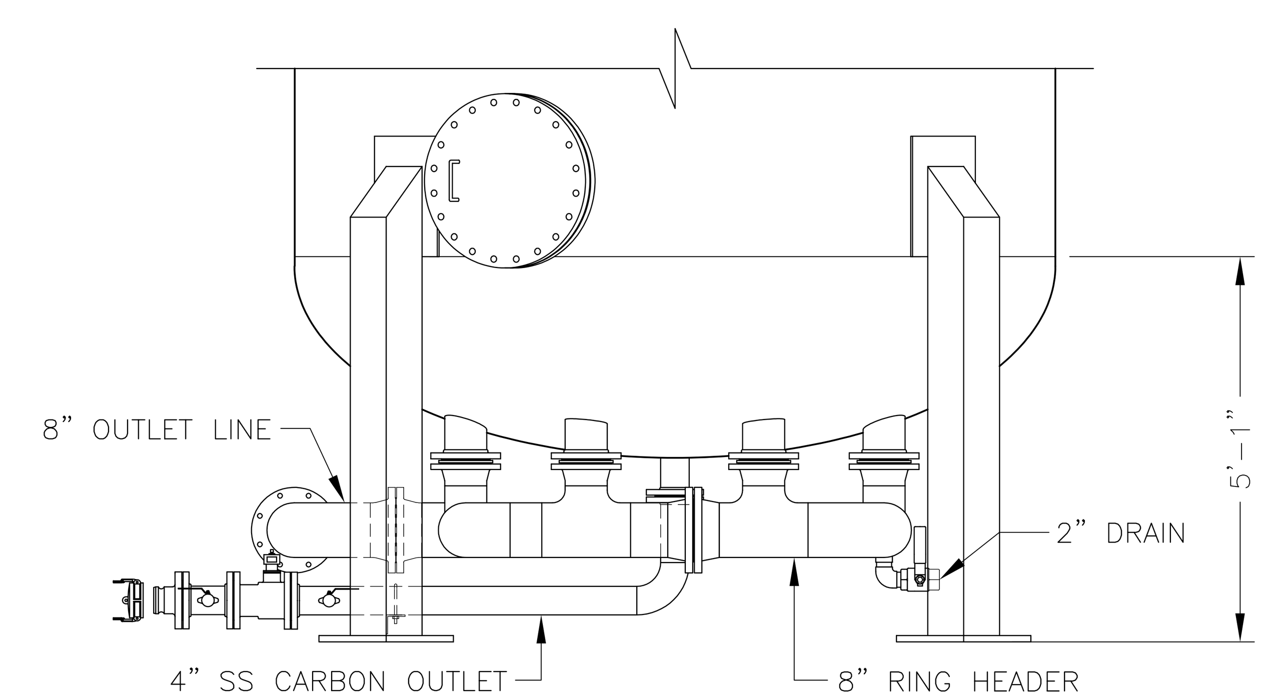
1. THIS DRAWING IS TO SHOW PIPING AND EQUIPMENT FOR CUSTOMER APPROVAL.
2. ALL BUTTERFLY VALVES ARE CAST IRON WITH STAINLESS TRIM, AL/BRNZ DISK.
3. PROVIDE STAINLESS STEEL SCREENS AT SEPTA UNDER DRAIN.
4. VESSELS SHALL BE CARBON STEEL 125 PSI, ASME CODE.
5. FINISH INTERIOR WITH PLASITE 4110, PREPARE AND APPLY STRICTLY IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS AND NSF STANDARD 61.
6. PIPING MATERIALS SHALL MEET: CS PIPE ASTM A-53 GRADE B (ERW); CS FITTINGS SA-234, ASME B16.9; SS THREADED FITTINGS ASTM A-351; SS PIPE ASTM A-312; SS BW FITTINGS ASTM A-403; MI THREADED FITTINGS ASME B-16.3.
7. FINISH EXTERIOR WITH URETHANE 3-4 MILL DFT OVER EPOXY PRIMER 4-6 MIL DFT APPLIED PER MANUFACTURERS RECOMMENDATIONS.
8. SYSTEM ESTIMATED WEIGHTS: SHIPPING: 38,500 LBS. OPERATING: 170,000 LBS.
9. GROUTING BY OTHERS IF REQUIRED.
10. DESIGNED FOR SEISMIC ZONE 4.
11. SYSTEM PROCESS CONNECTIONS: 8" 150# RF FLANGES, BOLTS STRADDLE CENTERLINE AS SHOWN.
12. CARBON CAPACITY: 20,000 LBS PER VESSEL.
13. MAX. PROCESS FLOW: 750 GPM SERIES 1500 GPM PARALLEL
14. TYPICAL BACKWASH RATE (8X30 CARBON 55°F): 710 GPM.
15. OPERATING TEMPERATURE 140° F MAX.



ELEVATION



SECTION A–A



SECTION B–B

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

DESIGNER TAC	DATE 1/27/05
CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
FILE:	
SCALE:	

TITLE
HP1020 125 PSI SYSTEM W/ 8" MANIFOLD
SALES DRAWING

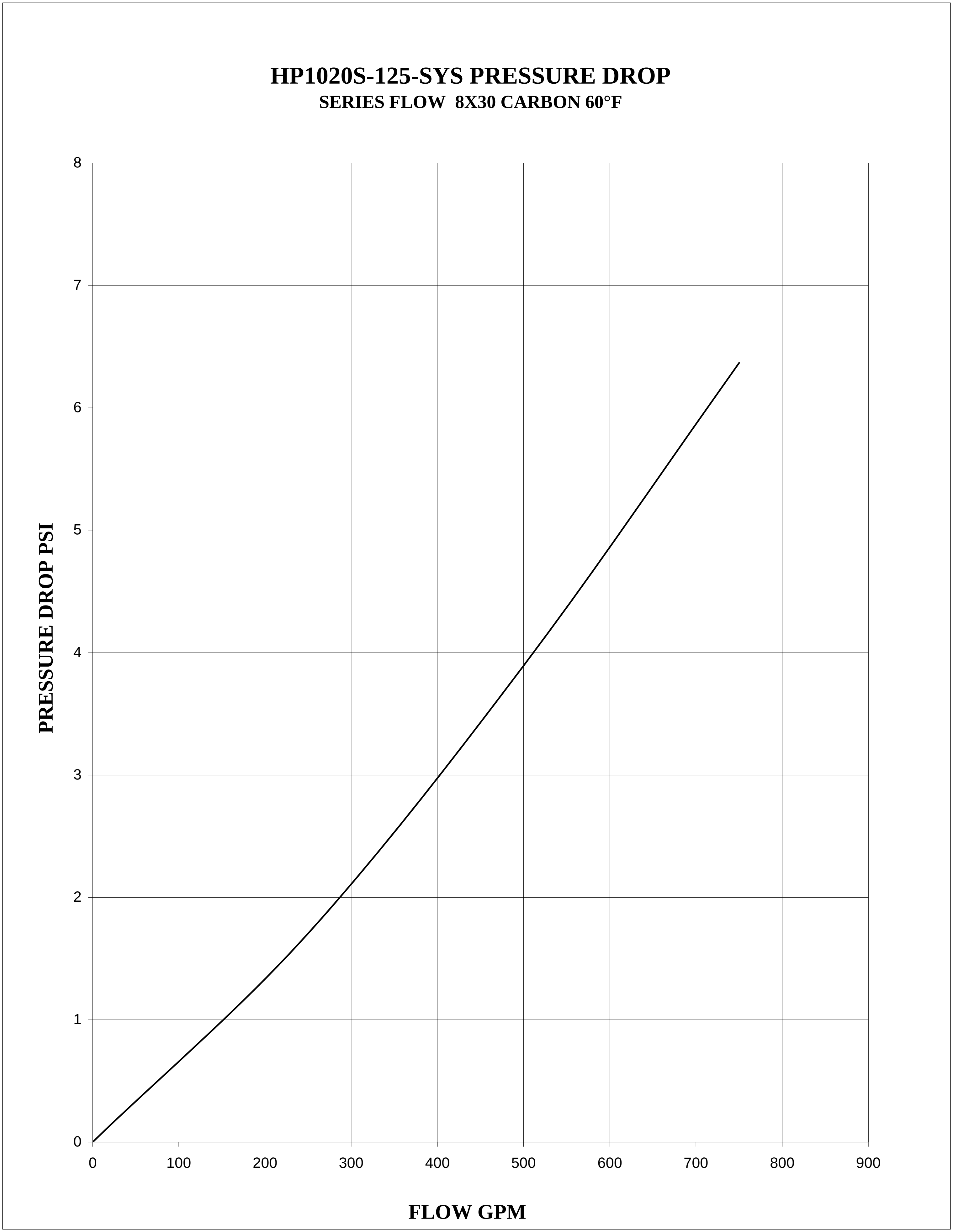
CLIENT

USFilter
USFILTER/WESTATES
RED BLUFF, CA
1-800-795-2664

PROJECT	DRAWING	SHEET	REV
	HP1020-SYS-Sales	1 OF 1	

STD: 2-0200-24X36D1

INTL REF:


HP1020S-125-SYS PRESSURE DROP
SERIES FLOW 8X30 CARBON 60°F
PRESSURE DROP PSI
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
600
700
800
900
FLOW GPM

JOB NAME	Red Hill Water Treatment				
JOB NO.	2008014	SHEET	1	OF	1
CALCULATED BY	HC	DATE	06/04/2009		
CHECKED BY		DATE			

Objective: To calculate the transfer pump capacity for pumping water from clear well to downstream GAC contactors

Q	=	16 mgd		Design capacity
	=	24.752 cfs		
	=	11104 gpm		
L	=	100 ft		Approximate pipe length
H2	=	15 ft		Static Head
C	=	130		
g	=	32.2		

Assume water velocity in pipe is

v = 3.5 ft/s

For design capacity, A = Q/v = 7.072 ft^2

Pipe cross-section area $A = pi*(D/2)^2$

D = 2*sqrt(A/pi) = 3.00072 ft = 36.009 in

Use D= 30.00 in = 2.5 ft

A = 4.91 ft^2

v = Q/A = 5.04 cf/s > 3.5 ft/s

Find dynamic headloss using Hazen-Willams equation:

$h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$ = 0.25392 ft

Total dynamic head (TDH):

Under dirty filter condition

TDH = Static Head + Dynamic head

= 15 + 0.25

= 15.25 ft

Say 16 ft

Design horsepower

BHP = Q(TDH)/(3958E) = 64 hp

Subject: **Red Hill**
Date: 7/10/2009 12:09:08 PM Hawaiian Standard Time
From: brantw@earthlink.net
To: esiKAILUA@aol.com

Scotty,

For the 5 Stage 17H, the pump budget estimate is approx $98K. The motor for this pump will be 900 HP (we can not quite hold 800 with column losses and trim allowance). The budget on the motor (I assumed VHS WP-I, 2300 V) is $65K.

For the 7 Stage 17H, the pump budget estimate is approx $115K. The motor for this pump will be 1250 HP (we can not quite hold 800 with column losses and trim allowance). The budget on the motor (I assumed VHS WP-I, 2300 V) is $90K

For the 20" 5721, the pump and base will be about $75K. Motor will be approx $30K. This is for a Horizontal, WP-I motor. This is pretty price for a small motor...because this is such a low low speed. This will be a special motor. We may even have a hard time finding a motor this small...at this low low speed. As such, I am not super confident on the price. We could get burned with such an odd motor.

For the 24" 5721, the pump and base will be about $105K. Motor will be approx $35K. This is for a Horizontal, WP-I motor.

For the 20" 5722, the pump and base will be about $130K (This is a big pump). Motor will be approx $40K. This is for a Horizontal, WP-I motor.

Let me know what else you need on this one.

Thanks,
-Brant

Brant Williams, Regional Manager - Western US
Fairbanks Morse Pump Company
14850 Highway 4, Suite A - #327
Discovery Bay, CA 94505
559.269.3931 (Mobile)
925.265.2265 (Fax)

Pump Data Sheet - Fairbanks Morse Pump, 60 Hz

Company: Engineered Systems Hawaii
Name: Paul Scott
Date: 7/7/2009

Fairbanks Morse
Pentair Water

Pump:

Size: 24"5711 (L)

Type: 5700ANGLEFLO
Synch speed: 400 rpm

Speed: 390 rpm
Dia: 24.25 in

Curve: 112418L

Impeller: L24A1L

Specific Speeds:

Ns: 4126
Nss: 7831

Dimensions:

Suction: 24 in
Discharge: 24 in

Pump Limits:

Temperature: 150 °F
Pressure: 50 psi g
Sphere size: 9 in

Power: ---
Eye area: ---

Search Criteria:

Flow: 11100 US gpm

Head: 16 ft

Fluid:

Water
Density: 62.25 lb/ft³
Viscosity: 1.105 cP

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

NPSHa: ---

Motor:

Standard: NEMA
Enclosure: TEFC

Speed: ---
Frame: ---

Sizing criteria: Max Power on Design Curve

---- Data Point ----

Flow:	11100 US gpm
Head:	16.1 ft
Eff:	83%
Power:	54.1 hp
NPSHr:	9.83 ft

---- Design Curve ----

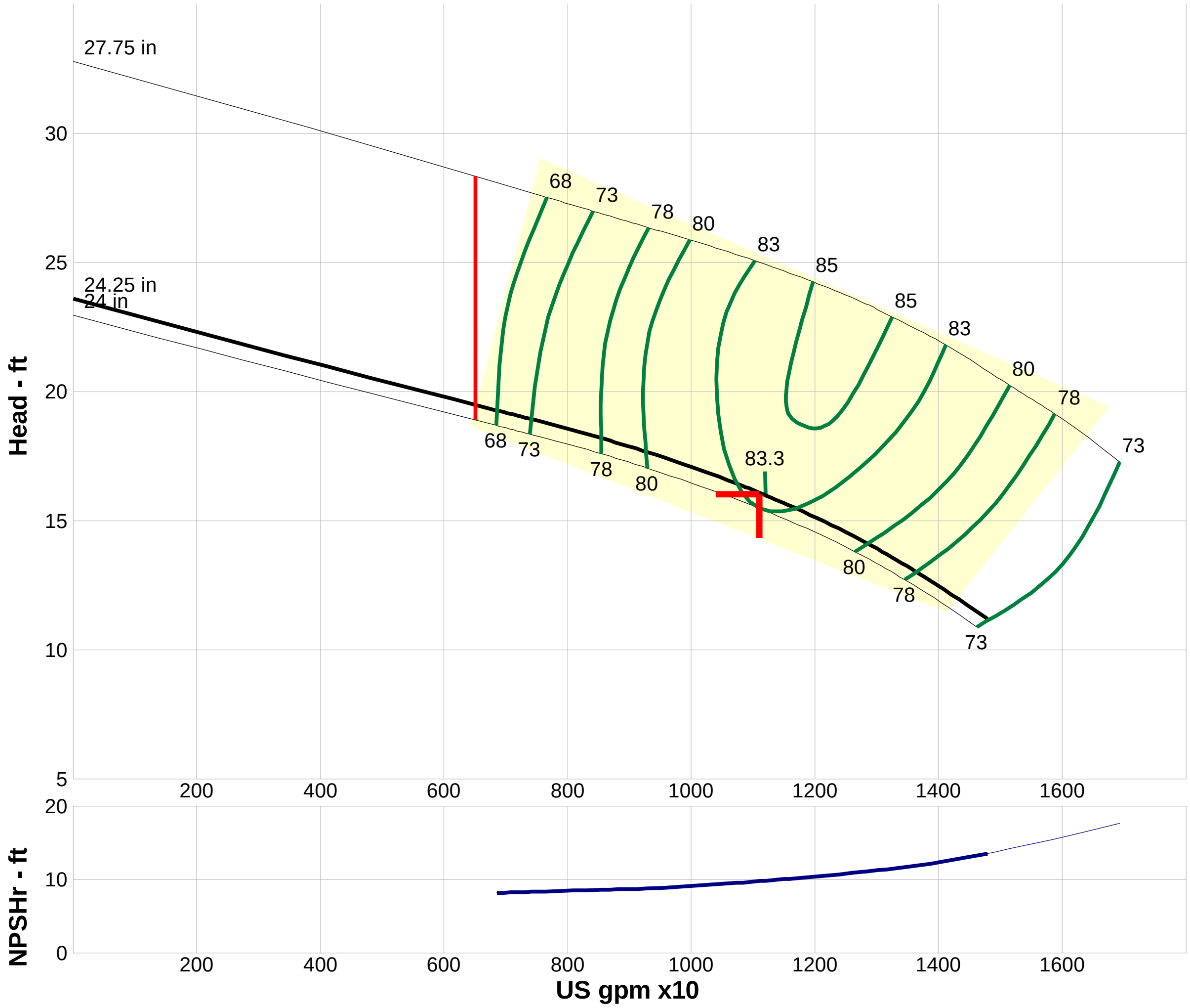
Shutoff head:	23.6 ft
Shutoff dP:	10.2 psi
Min flow:	6500 US gpm

BEP: 83% @ 11195 US gpm

NOL power:
57.5 hp @ 13631 US gpm

-- Max Curve --

Max power:
101 hp @ 16924 US gpm



Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
13320	390	13.5	79	57.4	11.6
11100	390	16.1	83	54.1	9.83
8880	390	18	79	50.9	8.74
6660	390	19.4	66	49.2	8.18
4440	390	---	---	---	---

⚠ WARNING

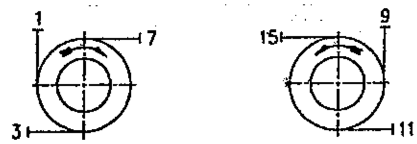
DO NOT OPERATE THIS MACHINE WITHOUT PROTECTIVE GUARD IN PLACE. ANY OPERATION OF THIS MACHINE WITHOUT PROTECTIVE GUARD CAN RESULT IN SEVERE BODILY INJURY.

—A— SUPPLIED BY FMPC —B— SUPPLIED BY OTHERS

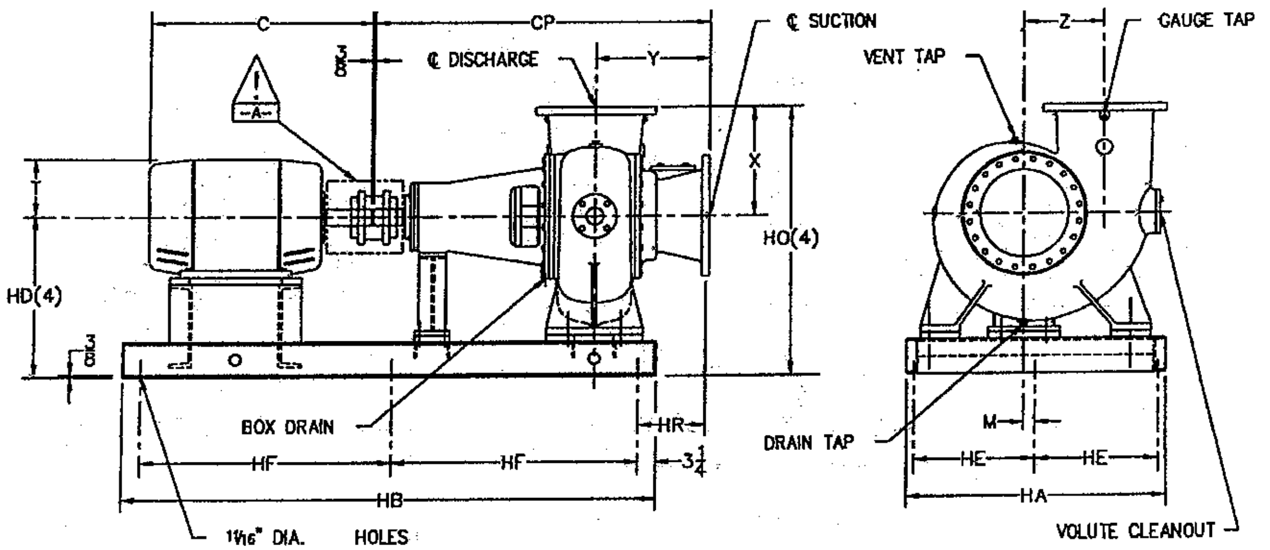
MOTOR DIMENSIONS	
C	T

AVAILABLE DISCHARGE POSITIONS

CLOCKWISE COUNTERCLOCKWISE



POSITIONS #1 OR #9 ARE STANDARD WHEN VIEWED FROM THE DRIVER END UNLESS OTHERWISE SPECIFIED. CLOCKWISE ROTATION DISCHARGE POSITION #1 SHOWN.



PUMP	MOTOR FRAME	SUCT	DISCH	M	X	Y	Z	CP	HA	HB	HD	HE	HF	HO	HR
8" C5721		8	8	NA	10	14	7 1/4	40 5/8	30 1/2	CF	19	14 1/2	CF	29	10 1/2
20" C5721L		20	20	NA	25	26	18	76 5/8	58	CF	36 1/2	27 1/2	CF	61 1/2	16
20" C5721S		20	20	NA	25	26	18	76 5/8	58	CF	36 1/2	27 1/2	CF	61 1/2	16
24" C5721		24	24	3	30	30	20 5/8	92	64	CF	44 1/2	30 3/4	CF	74 1/2	18
30" C5721		30	30	4	37 1/2	36	27 1/4	109 3/4	78	CF	53 3/4	37 3/4	CF	91 1/4	21
36" C5721		36	36	7	39	46	33 3/4	133	96	CF	65 3/4	45 3/4	CF	104 3/4	28

CF = CONSULT FACTORY ON THESE DIMENSIONS.

NOTES:
(1) ALL FLANGES ARE 125# ANSI DRILLING UNLESS NOTED.
(2) ALL DIMENSIONS ARE IN INCHES UNLESS NOTED.
(3) BASES ARE DESIGNED TO BE COMPLETELY FILLED WITH GROUT.
(4) FOR DISCHARGE POSITIONS OTHER THAN #1 OR #9 REFER TO FACTORY FOR DIMENSIONS.
(5) NOT FOR CONSTRUCTION, INSTALLATION, OR APPLICATION PURPOSES UNLESS CERTIFIED. DIMENSIONS SHOWN MAY VARY DUE TO NORMAL MANUFACTURING TOLERANCES.

CUSTOMER				P.O. NO.		Fairbanks Morse Pentair Water
JOB NAME				TAG NAME		
PUMP SIZE AND MODEL		GPM	TDH	RPM	ROTATION	DISCH POS
MOTOR	HP	FRAME	PHASE	HERTZ	VOLTS	ENCLOSURE
CERTIFIED FOR			CERTIFIED BY		DATE	

SETTING PLAN
8", 20" THRU 36" C5721
STRUCTURAL BASE

DWG NO 5720S029 REV NO 2

Objective: To calculate the transfer pump capacity for pumping water from the secondary GAC clear well to storage tanks S-1 and S-2 (Alternative 1)

Q	=	16	mgd	Design capacity
	=	24.752	cfs	
	=	11104	gpm	
L	=	263	ft	Approximate pipe length
H	=	63	ft	Static Head
C	=	130		
g	=	32.2		

Assume water velocity in pipe is

v = 3.5 ft/s

For design capacity, A = Q/v = 7.072 ft^2

Pipe cross-section area A = pi*(D/2)^2

D = 2*sqrt(A/pi) = 3.00072 ft = 36.008699 in

Use D= 30.00 in = 2.5 ft

A = 4.91 ft^2

v = Q/A = 5.04 cf/s > 3.5 ft/s

Find dynamic headloss using Hazen-Willams equation:

$h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$ = 0.66782 ft

Total dynamic head (TDH):

Under dirty filter condition

TDH = Static Head + Dynamic head

= 63 + 0.67

= 63.67 ft

Say 64 ft

Design horsepower

BHP = Q(TDH)/(3958E) = 256 hp

Pump Data Sheet - Fairbanks Morse Pump, 60 Hz

Company: Engineered Systems Hawaii
Name: Paul Scott
Date: 7/7/2009

Fairbanks Morse
Pentair Water

Pump:

Size: 20"5712

Type: 5700ANGLEFLO
Synch speed: 720 rpm

Speed: 705 rpm
Dia: 25.75 in

Curve: 122010A

Impeller: L20C1A

Specific Speeds:

Ns: 2746
Nss: 7327

Dimensions:

Suction: 24 in
Discharge: 20 in

Pump Limits:

Temperature: 150 °F
Pressure: 70 psi g
Sphere size: 8 in

Power: ---
Eye area: ---

Search Criteria:

Flow: 11100 US gpm

Head: 64 ft

Fluid:

Water
Density: 62.25 lb/ft³
Viscosity: 1.105 cP

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

NPSHa: ---

Motor:

Standard: NEMA
Enclosure: TEFC

Speed: ---
Frame: ---

Sizing criteria: Max Power on Design Curve

---- Data Point ----

Flow:	11100 US gpm
Head:	64.1 ft
Eff:	86%
Power:	209 hp
NPSHr:	22.6 ft

---- Design Curve ----

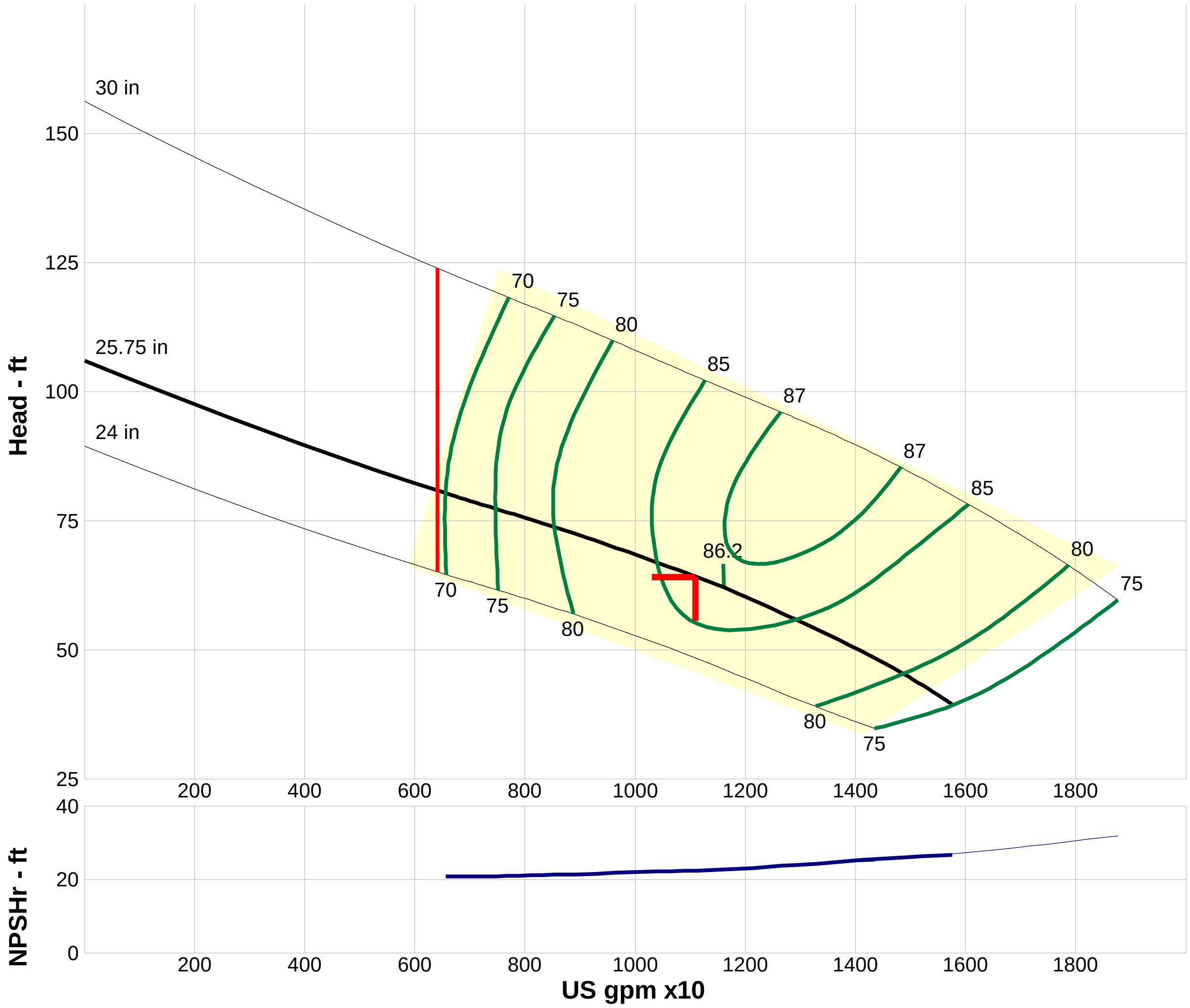
Shutoff head:	106 ft
Shutoff dP:	45.8 psi
Min flow:	6400 US gpm

BEP: 86% @ 11597 US gpm

NOL power:
214 hp @ 12905 US gpm

-- Max Curve --

Max power:
377 hp @ 18750 US gpm



Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valorес garantizados contacte a Fairbanks Morse o a su distribuidor local.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
13320	705	53.7	84	214	24.5
11100	705	64.1	86	209	22.6
8880	705	72.5	81	200	21.6
6660	705	80	71	190	21
4440	705	---	---	---	---

⚠ **WARNING**

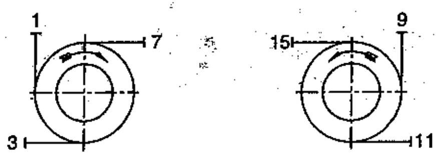
DO NOT OPERATE THIS MACHINE WITHOUT PROTECTIVE GUARD IN PLACE. ANY OPERATION OF THIS MACHINE WITHOUT PROTECTIVE GUARD CAN RESULT IN SEVERE BODILY INJURY.

-A- SUPPLIED BY FMPC -B- SUPPLIED BY OTHERS

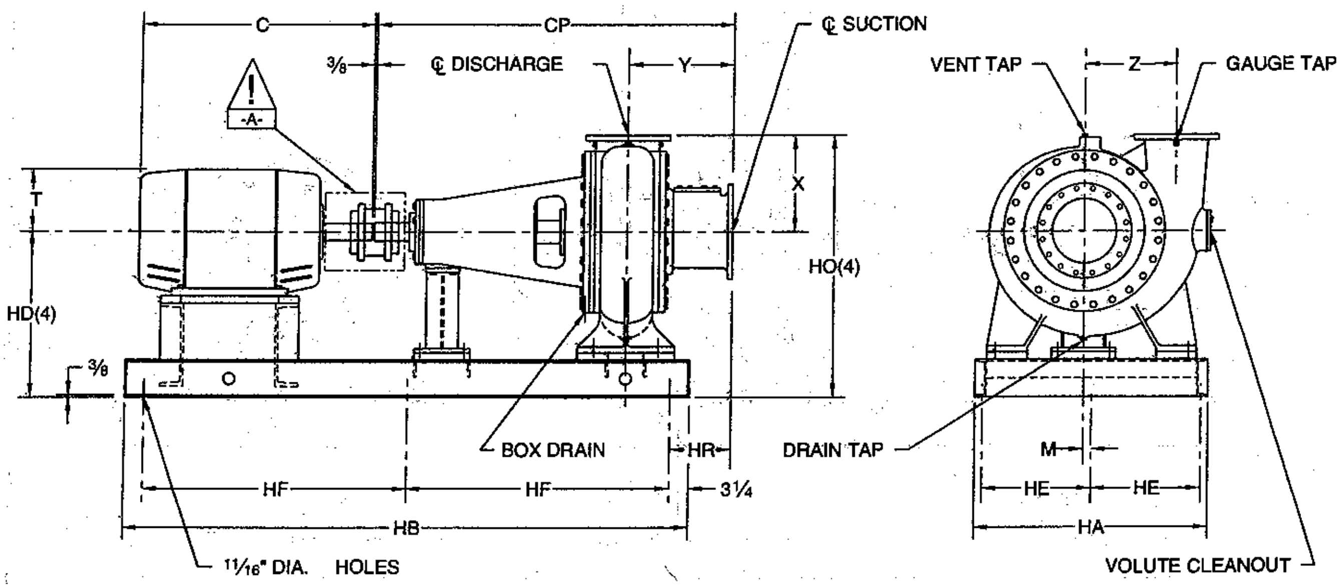
MOTOR DIMENSIONS	
C	T

AVAILABLE DISCHARGE POSITIONS

CLOCKWISE COUNTERCLOCKWISE



POSITIONS #1 OR #9 ARE STANDARD WHEN VIEWED FROM THE DRIVER END UNLESS OTHERWISE SPECIFIED. CLOCKWISE ROTATION DISCHARGE POSITION #1 SHOWN.



PUMP	SUCT	DISCH	X	Y	Z	CP	M	HA	HB	HD	HE	HF	HO	HR
14" C5722	16	14	24	26	22¾	88⅞	2	58			27½			15
20" C5722	24	20	30	30	18¾	93⅜	4	62			29½			19
24" C5722	30	24	40	27	26½	96⅛	CONSULT FACTORY							

NOTES:
(1) ALL FLANGES ARE 125# ANSI DRILLING UNLESS NOTED.
(2) ALL DIMENSIONS ARE IN INCHES UNLESS NOTED.
(3) BASES ARE DESIGNED TO BE COMPLETELY FILLED WITH GROUT.
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(5) NOT FOR CONSTRUCTION, INSTALLATION, OR APPLICATION PURPOSES UNLESS CERTIFIED. DIMENSIONS SHOWN MAY VARY DUE TO NORMAL MANUFACTURING TOLERANCES.

CUSTOMER				P.O. NO.	
JOB NAME				TAG NAME	
PUMP SIZE AND MODEL	GPM	TDH	RPM	ROTATION	DISCH POS
MOTOR	HP	FRAME	PHASE	HERTZ	VOLTS	ENCLOSURE
CERTIFIED FOR		CERTIFIED BY		DATE	

Fairbanks Morse Pump Corporation

SETTING PLAN
14", 20", & 24" C5722
STRUCTURAL BASE

DWG NO 5720S033 REV NO 0

JOB NAME	Red Hill Water Treatment		
JOB NO.	2008014	SHEET	1 OF 1
CALCULATED BY	HC	DATE	06/04/2009
CHECKED BY		DATE	

Objective: To calculate the transfer pump capacity for pumping water from the secondary GAC clear well to new on-site storage tank for Alternatives 2 and 3

Q	=	16	mgd	Design capacity
	=	24.752	cfs	
	=	11104	gpm	
L	=	241	ft	Approximate pipe length
H	=	41	ft	Static Head
C	=	130		
g	=	32.2		

Assume water velocity in pipe is
v = 3.5 ft/s

For design capacity, A = Q/v = 7.072 ft^2

Pipe cross-section area A = $pi*(D/2)^2$
D = 2*sqrt(A/pi) = 3.00072 ft = 36.008699 in
Use D= 30.00 in = 2.5 ft
A = 4.91 ft^2
v = Q/A = 5.04 cf/s > 3.5 ft/s

Find dynamic headloss using Hazen-Willams equation:
$h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$ = 0.61195 ft

Total dynamic head (TDH):
Under dirty filter condition
TDH = Static Head + Dynamic head
= 41 + 0.61
= 41.61 ft
Say 42 ft

Design horsepower
BHP = Q(TDH)/(3958E) = 168 hp

Pump Data Sheet - Fairbanks Morse Pump, 60 Hz

Company: Enginneered System Hawaii
Name: Paul Scott
Date: 7/20/2009

Fairbanks Morse
Pentair Water

Pump:

Size: 20"5711S
Type: 5700ANGLEFLO
Synch speed: 600 rpm
Speed: 585 rpm
Dia: 23.9375 in
Curve: 112012S
Impeller: L20A1S
Specific Speeds:
Ns: 4025
Nss: 7394
Dimensions:
Suction: 20 in
Discharge: 20 in

Pump Limits:

Temperature: 150 °F
Pressure: 50 psi g
Sphere size: 7.5 in
Power: ---
Eye area: ---

Search Criteria:

Flow: 11100 US gpm
Head: 42 ft

Fluid:

Water
SG: 1
Viscosity: 1.105 cP
NPSHa: ---
Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

Motor:

Standard: NEMA
Enclosure: TEFC

Speed: ---
Frame: ---
Sizing criteria: Max Power on Design Curve

---- Data Point ----

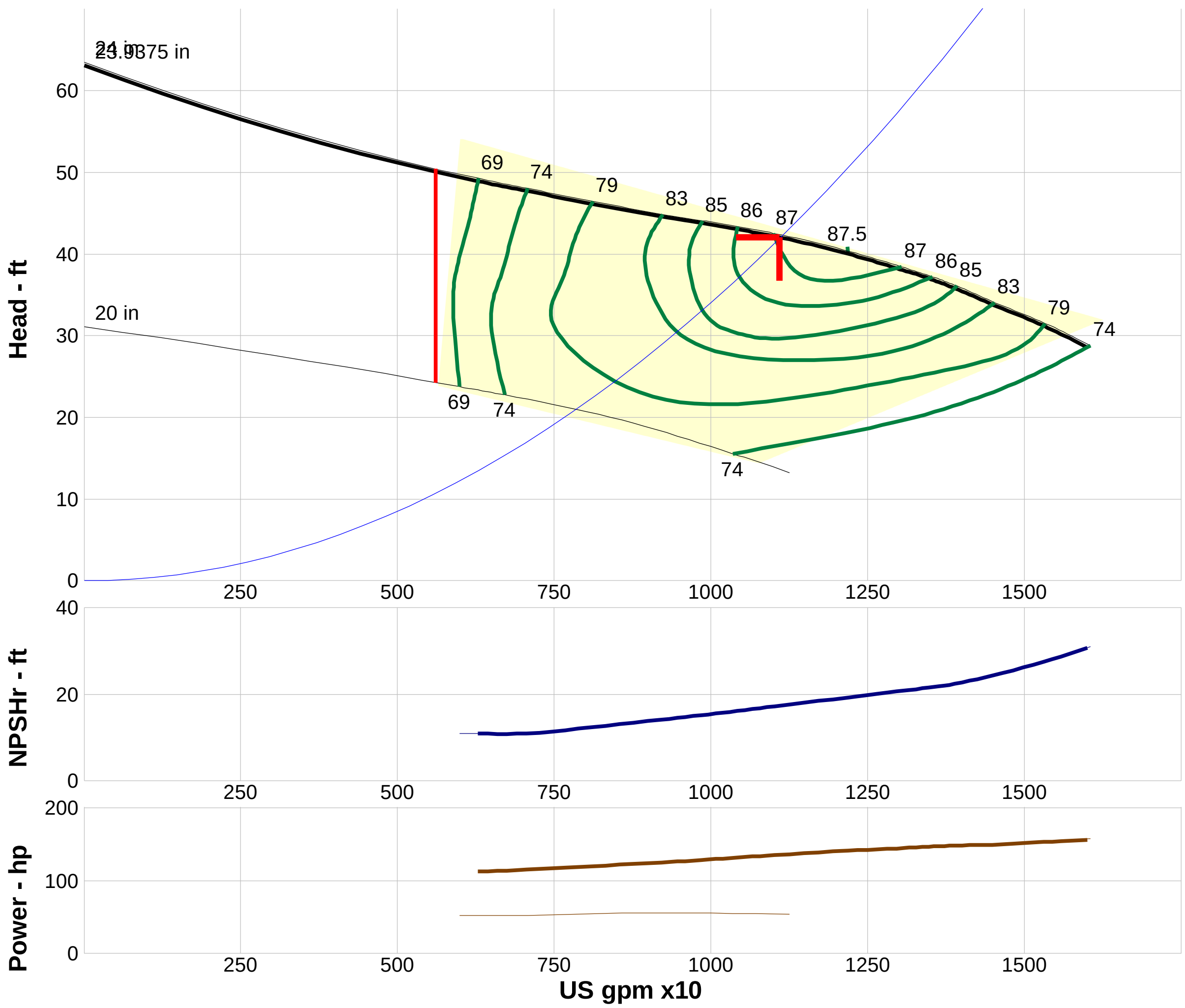
Flow: 11100 US gpm
Head: 42 ft
Eff: 87%
Power: 135 hp
NPSHr: 17.4 ft

---- Design Curve ----

Shutoff head: 63.1 ft
Shutoff dP: 27.3 psi
Min flow: 5600 US gpm
BEP: 87% @ 12179 US gpm
NOL power:
156 hp @ 15994 US gpm

-- Max Curve --

Max power:
158 hp @ 16044 US gpm



Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
13320	585	37.4	86	146	21.3
11100	585	42	87	135	17.4
8880	585	45	82	123	13.7
6660	585	48.3	71	114	11
4440	585	---	---	---	---

Selected from catalog: Fairbanks Morse Centrifugal.60 Vers: 3

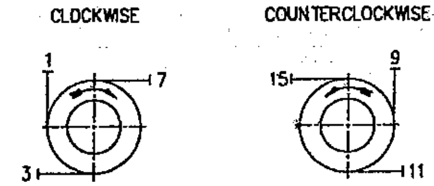
WARNING

DO NOT OPERATE THIS MACHINE WITHOUT PROTECTIVE GUARD IN PLACE. ANY OPERATION OF THIS MACHINE WITHOUT PROTECTIVE GUARD CAN RESULT IN SEVERE BODILY INJURY.

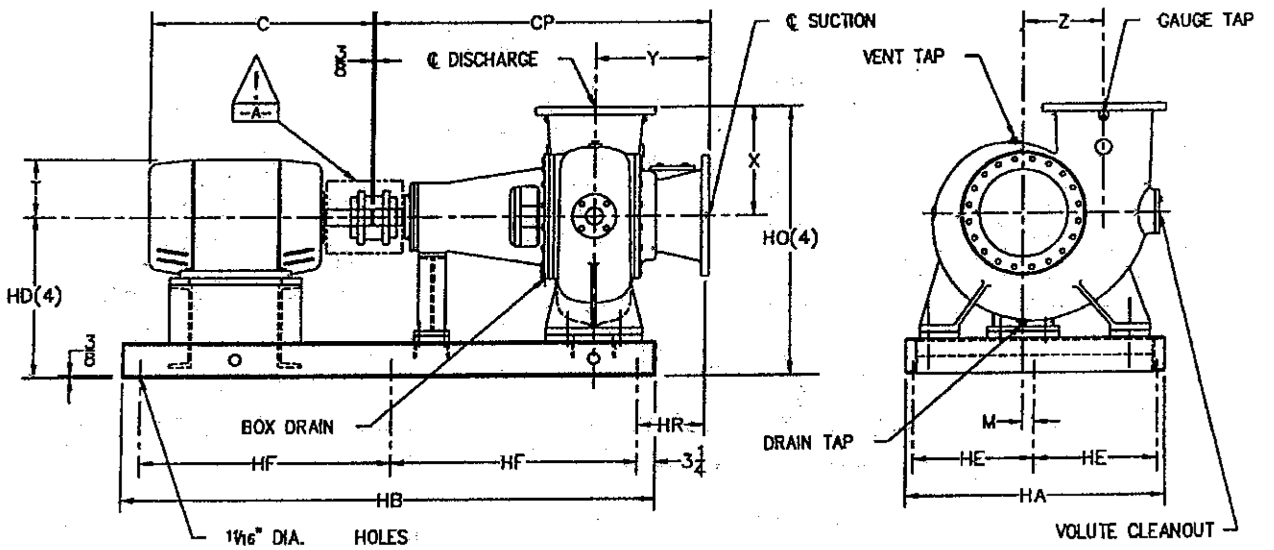
–A– SUPPLIED BY FMPC –B– SUPPLIED BY OTHERS

MOTOR DIMENSIONS	
C	T

AVAILABLE DISCHARGE POSITIONS



POSITIONS #1 OR #9 ARE STANDARD WHEN VIEWED FROM THE DRIVER END UNLESS OTHERWISE SPECIFIED. CLOCKWISE ROTATION DISCHARGE POSITION #1 SHOWN.



PUMP	MOTOR FRAME	SUCT	DISCH	M	X	Y	Z	CP	HA	HB	HD	HE	HF	HO	HR
8" C5721		8	8	NA	10	14	7¼	40⅝	30½	CF	19	14½	CF	29	10½
20" C5721L		20	20	NA	25	26	18	76⅝	58	CF	36½	27½	CF	61½	16
20" C5721S		20	20	NA	25	26	18	76⅝	58	CF	36½	27½	CF	61½	16
24" C5721		24	24	3	30	30	20⅝	92	64	CF	44½	30¾	CF	74½	18
30" C5721		30	30	4	37½	36	27¼	109¾	78	CF	53¾	37¾	CF	91¼	21
36" C5721		36	36	7	39	46	33¾	133	96	CF	65¾	45¾	CF	104¾	28

CF = CONSULT FACTORY ON THESE DIMENSIONS.

NOTES:
(1) ALL FLANGES ARE 125# ANSI DRILLING UNLESS NOTED.
(2) ALL DIMENSIONS ARE IN INCHES UNLESS NOTED.
(3) BASES ARE DESIGNED TO BE COMPLETELY FILLED WITH GROUT.
(4) FOR DISCHARGE POSITIONS OTHER THAN #1 OR #9 REFER TO FACTORY FOR DIMENSIONS.
(5) NOT FOR CONSTRUCTION, INSTALLATION, OR APPLICATION PURPOSES UNLESS CERTIFIED. DIMENSIONS SHOWN MAY VARY DUE TO NORMAL MANUFACTURING TOLERANCES.

CUSTOMER					P.O. NO.	
JOB NAME					TAG NAME	
PUMP SIZE AND MODEL		GPM	TDH	RPM	ROTATION	DISCH POS
MOTOR	HP	FRAME	PHASE	HERTZ	VOLTS	ENCLOSURE
CERTIFIED FOR			CERTIFIED BY		DATE	

Fairbanks Morse
Pentair Water

SETTING PLAN
8", 20" THRU 36" C5721
STRUCTURAL BASE

DWG NO 5720S029 REV NO 2

JOB NAME	Red Hill Water Treatment		
JOB NO.	2008014	SHEET	1 OF 1
CALCULATED BY	HC	DATE	6/4/2009
CHECKED BY		DATE	

Objective: To determine the new water storage tank size.

Q	=	16 mgd		Design capacity
	=	24.752 cfs		
	=	11104 gpm		

Assume on-site for 15 min storage

V = 22277 cf — Tank volume

Assume tank height h = 25 ft -> A = V/h = 891.1 ft^2

Tank cross-section area $A = pi*(D/2)^2$

D = 2*sqrt(A/pi) = 33.6831 ft

Use tank diameter D = 34 ft

-> h = 24.536 ft say 26 ft

-> Tank diamter = 34 ft

Tank height = 26 ft

QUOTE FOR: HDR
Wendy Chen
1132 Bishop St. Suite 1003
Honolulu, Hawaii
Telephone: 808-440-8495
Email: wendy.chen@hdrinc.com

1712 19th Street, Suite 109
Bakersfield, CA 93301
Phone: 661-636-1357
Fax: 661-636-1329

Quote Number: 0906-8907 **Date:** 06/24/2009

Reference: Red Hill Water Treatment Pearl Harbor

Thank you for your inquiry. We are pleased to offer the following quotation for your consideration.

- **DESCRIPTION - Item 1**

1 -34.165' Diameter x26.12' nominal sidewall height factory coated bolted carbon steel Water storage tank, specific gravity of 1.00, nominal capacity 179,125 gallons, usable capacity 168,839 gallons based on 1.500' of freeboard, designed in accordance with AWWA D103-97 Specifications, Seismic Zone1, I = 1.00, Rw = 3.50, S = 1.50 per AWWA,100 MPH wind load per AWWA, 25 PSF live deck load, Flat steel bottom, Center supported 1:12 slope roof

NOTE: It is the customer's responsibility to notify CTT if design conditions are other than noted.

- **COATINGS**

Interior and both sides of bottom painted one coat of Trico Bond EP® thermoset corrosion resistant powder epoxy (7 mils average, DFT). Z-Bond EP™ exterior 3-coat system consisting of one coat of zinc rich primer (2.0 mils average, DFT), one intermediate coat of Trico Bond EP® thermoset corrosion resistant powder epoxy (5 mils average, DFT) and one topcoat of performance urethane (1.5 mils average DFT). (Total 8.5 mils DFT). (Color other than tan optional at an additional charge of $500.00 per order).

- **HARDWARE**

Galvanized bolts, nuts, washers and EPDM gasketing. Plastic encapsulated head bolts for interior vertical and roof seams.

- **ACCESSORIES**

1- Columbian TecTank decal installed on top ring
1- Mushroom vent with insect screen
1- 24" Square roof manway with hinged cover
1- 24" X 46" Flush cleanout with 2-piece cover
1- Name Plate, Liquid NSF Tank
1- Outside ladder with safety cage and lockable entry hoop - OSHA - hot dip galvanized (CTT standard construction)
1- 10' Partial perimeter guardrail with handrail and toe board
1- Liquid level indicator with gauge board
1- 6" 150# flat-faced single flanged nozzle
1- 6" 150# flat-faced single flanged nozzle
1- 6" 150# flat-faced single flanged nozzle
1- 8" Internal overflow weir cone with external Sch. 10 downcomer pipe and flap gate
1- 12 GA x 6" high grade band
1- PE Stamps

TERMS AND CONDITIONS OF SALE

The Terms and Conditions of this Offer are per the attached Terms and Conditions of Sale for Columbian TecTank Product Lines. Please review these terms carefully, particularly the sections concerning Terms of Payment, Invoice& Hold, and Taxes.

SCHEDULE

Approximately 8-10 weeks after receipt of returned approval drawings and settlement of all details. Please allow 2-4 weeks for preparation of approval drawings. If this indicated time is not satisfactory, then we will work with you on your delivery schedule.

- **EXCEPTIONS/CLARIFICATIONS**

General

1. Columbian TecTank is submitting this quotation for a bolted tank.
2. The tank is designed and fabricated per AWWA D103-97 Specifications for bolted steel tanks.
3. This quote does not include unloading of tank.
4. This quote does not include disinfection at jobsite.
5. Foundation designed by others. All foundation work shall be by others.
6. Tank nozzles will be factory cutout and bolt on in the field.
7. Unless noted, all equipment that is to be attached to the tank to be installed by the customer. This includes alarms, gauges, insulation, and heating equipment and controls.
8. Grouting is not included.
9. If required, Lightning Protection Equipment provided by the customer.
10. Unless noted, corrosion allowance has not been added to this quotation.
11. Unless noted, Columbian TecTank has quoted our standards for design, fabrication, guardrails, ladders and coatings.

12. Cathodic Protection has not been quoted nor is it required on Trico Bond EP® coated tanks.
13. Unless noted, there is no piping (interior or exterior) quoted.
14. Unless noted, external or internal piping or piping brackets have not been quoted.
15. Prices are firm for 30 days (CS only)and do not include any fees, permits, duties or applicable taxes.

NOTE: *Any items or specifications not specifically mentioned above are not a part of this quotation. This quotation represents our completeoffering. If there are any conflicts between your requirements or the plans and specifications and what we have quoted, our quotation shall govern.*

NOTE: Engineering calculations are available with submittal drawings for a charge of $250.00. Three sets of drawings are provided for each size tank. Additional sets of drawings can be furnished for $15.00 per set. Specific State Professional Engineers Seal on drawings and calculations can also be furnished for $250.00

Governing Codes: Columbian TecTank Company utilizes those standards, specifications and/or interpretations and recommendations of professionally recognized agencies and groups such as AWWA, API, ACI, AISI, AWS ASTM, Factory Mutual, U.S. Government, etc. as the basis in establishing its own design, fabrication and quality criteria, standards, practices, methods and tolerances.

We trust our prices and delivery will meet your approval and that we may be favored with your order.

Sincerely,

David Oveson
Regional Manager
661-636-1316
doveson@columbiantectank.com

PRICING SUMMARY

Item	Qty	Size	Material	Erection	Freight	Total	Weight
1	1	34.165' x 26.12'	$ 62,955	N/A	$ 5,000	$ 67,955	38,911

Prices are for quantities shown.

Freight has only been quoted knock down and to port of choice. If crating and transfer via ship are requested a price will be sent for this at that time.

Prices are firm for 30 days for Carbon Steel, Stainless Steel and Aluminum Alloy and do not include any fees, permits, duties or applicable taxes.

[ ] Resale Certificate - Provided to CTT by Customer

[ ] Tax Exempt Certificate - Provided to CTT by Customer

____

Signature

CTT's offer is accepted on

Date: ____

By: ____

Title: ____

The above signed represents that they are legally authorized to purchase on behalf of the company of __________________________________

Objective: To calculate the new booster pump capacity for alternative 1

D	=	6	in	Pipe diameter
	=	0.5	ft	
L	=	18450	ft	Approximate pipe length
H1	=	140	ft	Approximate tanks S-1/S-2 elevation
H2	=	590	ft	Approximate UST site elevation
h	=	40	ft	Approximate tank height
C	=	130		
g	=	32.2		

Assume water velocity in pipe is

v = 4 ft/s

Pipe cross-section area

A = 0.20 ft^2

Q = Av = 0.79 cf/s

= 352.64 GPM say 360 GPM

-> v = 4.083 ft/s

Find dynamic headloss using Hazen-Willams equation:

$h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$ = 207.448 ft

Total dynamic head (TDH):

Under dirty filter condition

TDH = Static Head + Dynamic head

= 490 + 207

= 697.45 ft

Say 700 ft

Design horsepower

BHP = Q(TDH)/(3958E) = 104 hp

QUOTATION

July 7, 2009

HDR, Inc., Attn: Wendy Chen

Subject: Red Hill Water Treatment Booster System, Rev. A

Dear Wendy,

We are pleased to offer the following equipment in accordance with your request:

(1) **Tigerflow** series VMS-4000-VFD, model TVMBV-50GF-C-S6-VFD UL/C-UL listed engineered packaged triplex variable speed domestic water booster system consisting of:

Condition point: 360 gpm @ 303 psi
Suction pressure: 0# min 10# max

(3) Grundfos series CR, size CR45-8-1 cast iron stainless fitted, mechanical seal, vertical multistage pumps each close-coupled to a 60 hp, 3600 rpm, 460/3/60, ODP high efficiency motor

*condition point: 180 gpm @ 700' tdh (each)

(1) low flow by-pass

(3) 3" 300# non-slam check valves

(1) Watts Model 1116-52 surge anticipating relief valve, epoxy coated and installed on the discharge line with isolation valve (set at 400 psi) to be piped to tank for to drain by others

(3) 150# isolation lug style butterfly valves

(3) 300# isolation lug style butterfly valves

(3) non-electric combination temperature probe & purge assemblies

(1) U.L. Listed, NEMA 4, Tiger's Eye Mark V, E-Series Solid State, Power and Control Panel
(*)U.L./C-U.L. 508 Label
(*)Micro Controller:
-Flash Memory
-EPROM Latched Main Memory
-Multi Level Security Passwords
(*)Touch screen operator interface Model B-6 with 6" Blue Scale screen
Functions Included:
-(PID) Pressure Sequencing with Read-out in PSI

-Suction and Discharge Pressure Read-out in PSI
-Event History Log
-Individual Pump Run Indication
-H-O-A Selectors
-Elapsed Time Meter
-Low Suction Alarm with On-Off Time Delays
-Low System with On-Off Time Delays
-High Suction "Energy Savings" Shutdown with On-Off Time Delays, Enable Disable
-High System Alarm with On-Off Time Delays
-Automatic Alternation of Equal Sized Pumps
-32-bit RISC Micro-Controller
-USB Port
-RS-232, RS-485, RS-422 Communication Ports

(1) Thru Door Disconnect(s) with Individual Motor Circuit Protection
(3) ABB Series ACH NEMA I, Variable Speed drives with PWM with built in 5% line reactors with thru-the-door circuit breaker disconnects
(*) 24 Volt U.L./C-U.L., CE Approved Switching Power Supply. Unit Must Have Built-In Breaker Bar with Over Demand Protection
(*) 120 Volt Fused Control Circuit Transformer
(1) Power on Light
(2) Common Auxiliary Alarm Contacts
(2) Panel Mtd. Stainless Pressure Transducers [(1) Suction, (1) Discharge]
(1) remote stop/start contacts from tank (by others)

(1 set) 6" stainless steel suction and discharge headers with flanged connections, 150# on suction side, 300# on discharge side

copper sensing lines

(1) steel system skid with all necessary pipe supports, tubing and wiring for complete package. Unit to be factory primed and painted with machine grade finish coat

(*) unit to be factory primed and painted with machine grade finish coat

System to be completely, electrically, hydrostatically and run tested before shipment

*all welding to be done by ASME code section 9 certified welders.

Each T**igerflow** package system is UL/C-UL listed as a system, so meeting OSHA and federal regulations 29CFR1910.303 and .399, as well as, NFPA pamphlet #70 (National Electric Code) article 90-7, City of Los Angeles approval code # M-980006 -CMR 248 Massachusetts State Plumbing code approval # P3-0198-45P.

BUDGET PRICE: $80,000

Estimated weight 3600#

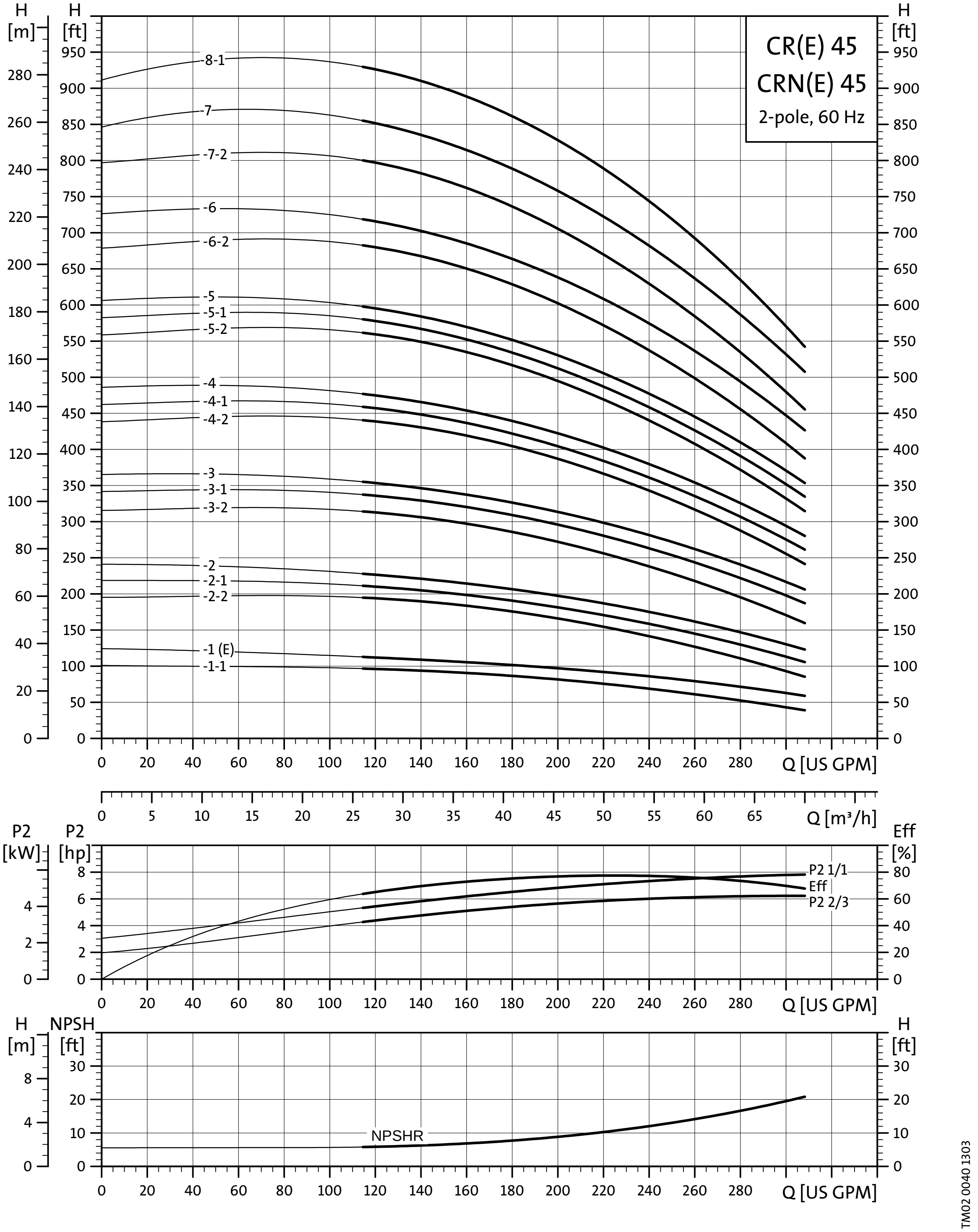
Price includes surface freight to Honolulu but does not include taxes. Shipment can be made in 6-8 weeks. Transit time is approximately 4 weeks. Price is good for 30 days.

Yours truly,

Hank Gellert

Hank Gellert, President
The Gellert Company
www.gellertco.com

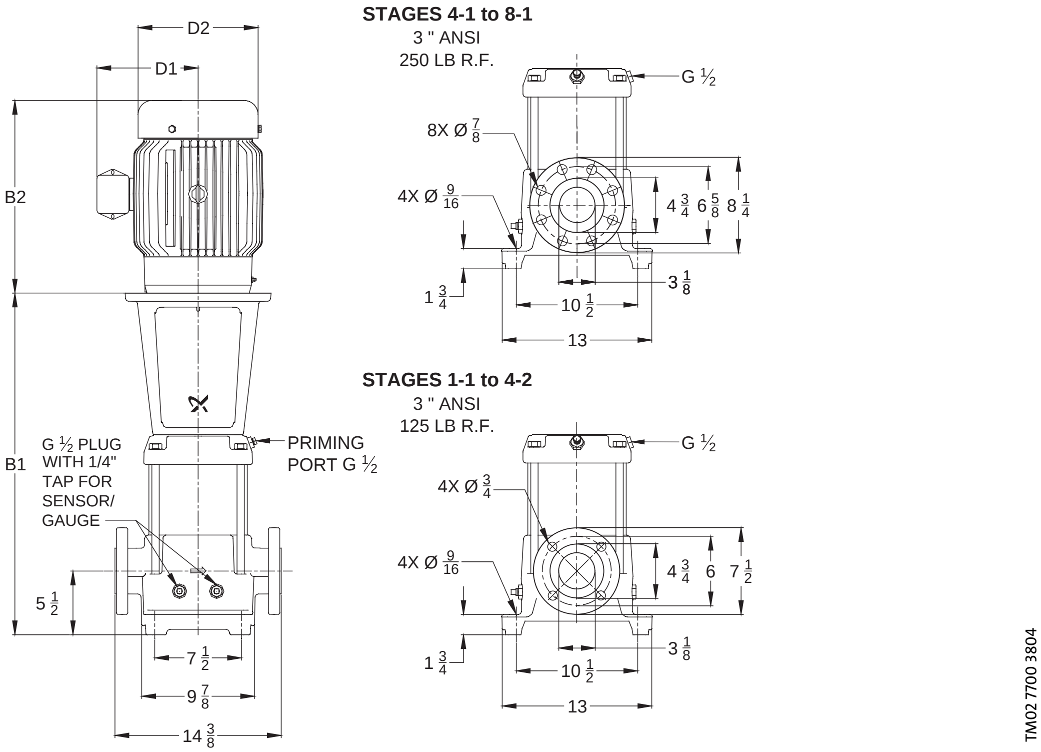
444 Waiakamilo Road, Honolulu, Hawaii 96817-4903 • TEL: (808) 847-2695 • FAX: (808) 847-1433
www.gellertco.com



CR(E) 45
CRN(E) 45
2-pole, 60 Hz
H [m]
H [ft]
-8-1
-7
-7-2
-6
-6-2
-5
-5-1
-5-2
-4
-4-1
-4-2
-3
-3-1
-3-2
-2
-2-1
-2-2
-1 (E)
-1-1
Q [US GPM]
Q [m³/h]
P2 [kW]
P2 [hp]
Eff [%]
P2 1/1
Eff
P2 2/3
NPSH [ft]
NPSHR
TM02 0040 1303

Technical data

Dimensional sketches



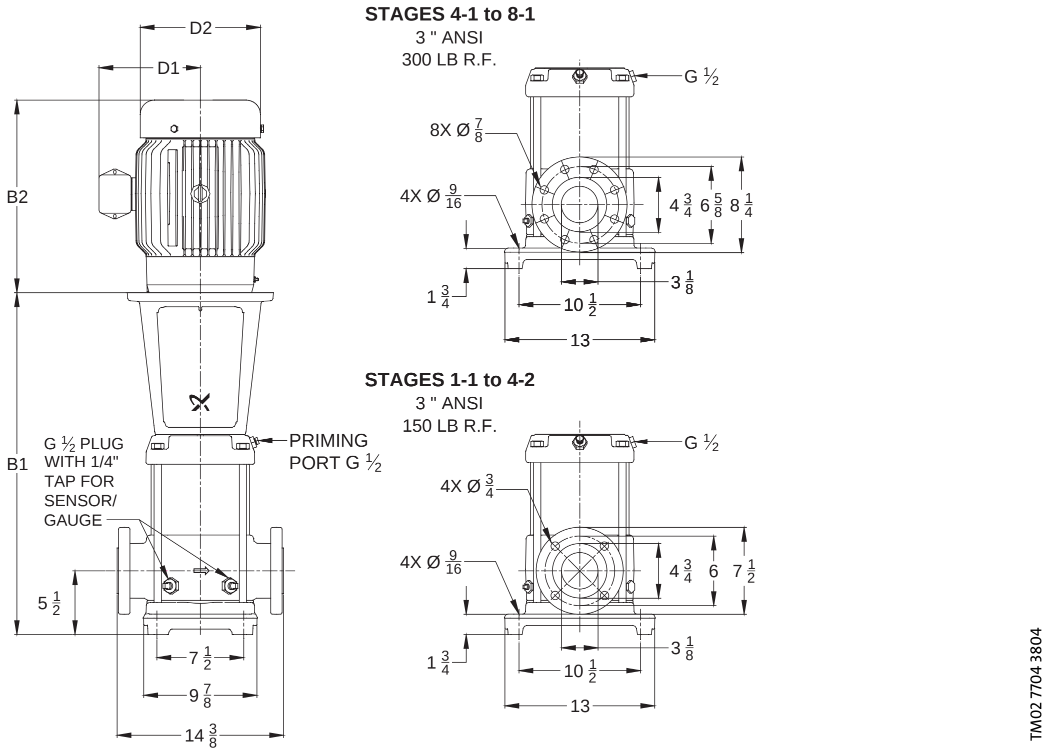
Dimensions and weights

Pump type	Hp	Ph	Voltage	NEMA Frame size	ANSI B1	TEFC			ODP			ANSI Ship Wt.[1] [lbs.]	MLE			ANSI Ship Wt.[1] [lbs.]
						D1	D2	ANSI B1+B2	D1	D2	ANSI B1+B2		D1	D2	ANSI B1+B2	
CR 45-1-1	7 1/2	1	208-230	213TC	22	10 1/4	7 1/2	37 3/8	-	-	-	301	-	-	-	-
		3	208-230/460	213TC	22	8 3/4	5 3/8	37 5/8	-	-	-	281	-	-	-	-
CR(E) 45-1	7 1/2	1	208-230	213TC	22	10 1/4	7 1/2	37 3/8	-	-	-	301	-	-	-	-
		3	208-230/460	213TC	22	8 3/4	5 3/8	37 5/8	-	-	-	281	8 3/4	7 1/2	37 2/5	311
CR 45-2-2	15	3	208-230/460	254TC	29 1/2	10 3/8	8 3/4	46 1/8	10 5/8	7 3/8	45 5/8	387	-	-	-	-
CR 45-2-1	15	3	208-230/460	254TC	29 1/2	10 3/8	8 3/4	46 1/8	10 5/8	7 3/8	45 5/8	387	-	-	-	-
CR 45-2	15	3	208-230/460	254TC	29 1/2	10 3/8	8 3/4	46 1/8	10 5/8	7 3/8	45 5/8	387	-	-	-	-
CR 45-3-2	20	3	230/460	254TC	32 5/8	10 3/8	8 3/4	49	11 1/2	9	50 5/8	569	-	-	-	-
CR 45-3-1	25	3	230/460	284TSC	32 5/8	13	9 1/2	52 3/8	11 1/2	9	53 5/8	622	-	-	-	-
CR 45-3	25	3	230/460	284TSC	32 5/8	13	9 1/2	52 3/8	11 1/2	9	53 5/8	622	-	-	-	-
CR 45-4-2	30	3	230/460	284TSC	35 3/4	15 3/8	13 1/8	58 3/4	11 1/2	9	57 3/8	809	-	-	-	-
CR 45-4-1	30	3	230/460	284TSC	35 3/4	15 3/8	13 1/8	58 3/4	11 1/2	9	57 3/8	809	-	-	-	-
CR 45-4	30	3	230/460	284TSC	35 3/4	15 3/8	13 1/8	58 3/4	11 1/2	9	57 3/8	809	-	-	-	-
CR 45-5-2	40	3	230/460	286TSC	39	15 3/8	13 1/8	62	13 1/4	12 1/4	62	863	-	-	-	-
CR 45-5-1	40	3	230/460	286TSC	39	15 3/8	13 1/8	62	13 1/4	12 1/4	62	863	-	-	-	-
CR 45-5	40	3	230/460	286TSC	39	15 3/8	13 1/8	62	13 1/4	12 1/4	62	863	-	-	-	-
CR 45-6-2	50	3	230/460	324TSC	42 1/8	17	14 1/8	69 3/4	13 3/8	12 1/4	64 5/8	929	-	-	-	-
CR 45-6	50	3	230/460	324TSC	42 1/8	17	14 1/8	69 3/4	13 3/8	12 1/4	64 5/8	929	-	-	-	-
CR 45-7-2	50	3	230/460	324TSC	45 1/4	17	14 1/8	72 7/8	13 3/8	12 1/4	67 3/4	938	-	-	-	-
CR 45-7	60	3	230/460	364TSC	45 1/4	19	15	75 7/8	15 1/4	13 1/4	71 1/4	1113	-	-	-	-
CR 45-8-1	60	3	230/460	364TSC	48 3/8	19	15	79	15 1/4	13 1/4	74 3/8	1113	-	-	-	-

Weights based on pump with TEFC motor (see price list for individual weights)
All dimensions in inches unless otherwise noted.

Technical data

Dimensional sketches



Dimensions and weights

Pump type	Hp	Ph	Voltage	NEMA Frame size	ANSI B1	TEFC D1	TEFC D2	TEFC ANSI B1+B2	ODP D1	ODP D2	ODP ANSI B1+B2	ANSI Ship Wt.[1] [lbs.]	MLE D1	MLE D2	MLE ANSI B1+B2	ANSI Ship Wt.[1] [lbs.]
CRN 45-1-1	7 1/2	1	208-230	213TC	22	10 1/4	7 1/2	37 3/8	-	-	-	301	-	-	-	-
		3	208-230/460	213TC	22	8 3/4	5 3/8	37 5/8	-	-	-	281	-	-	-	-
CRN 45-1	7 1/2	1	208-230	213TC	22	10 1/4	7 1/2	37 3/8	-	-	-	301	-	-	-	-
		3	208-230/460	213TC	22	8 3/4	5 3/8	37 5/8	-	-	-	281	8 3/4	7 1/2	37 2/5	311
CRN 45-2-2	15	3	208-230/460	254TC	29 1/2	10 3/8	8 3/4	46 1/8	10 5/8	7 3/8	45 5/8	387	-	-	-	-
CRN 45-2-1	15	3	208-230/460	254TC	29 1/2	10 3/8	8 3/4	46 1/8	10 5/8	7 3/8	45 5/8	387	-	-	-	-
CRN 45-2	15	3	208-230/460	254TC	29 1/2	10 3/8	8 3/4	46 1/8	10 5/8	7 3/8	45 5/8	387	-	-	-	-
CRN 45-3-2	20	3	230/460	254TC	32 5/8	10 3/8	8 3/4	49	11 1/2	9	50 5/8	569	-	-	-	-
CRN 45-3-1	25	3	230/460	284TSC	32 5/8	13	9 1/2	52 3/8	11 1/2	9	53 5/8	622	-	-	-	-
CRN 45-3	25	3	230/460	284TSC	32 5/8	13	9 1/2	52 3/8	11 1/2	9	53 5/8	622	-	-	-	-
CRN 45-4-2	30	3	230/460	284TSC	35 3/4	15 3/8	13 1/8	58 3/4	11 1/2	9	57 3/8	809	-	-	-	-
CRN 45-4-1	30	3	230/460	284TSC	35 3/4	15 3/8	13 1/8	58 3/4	11 1/2	9	57 3/8	809	-	-	-	-
CRN 45-4	30	3	230/460	284TSC	35 3/4	15 3/8	13 1/8	58 3/4	11 1/2	9	57 3/8	809	-	-	-	-
CRN 45-5-2	40	3	230/460	286TSC	39	15 3/8	13 1/8	62	13 1/4	12 1/4	62	863	-	-	-	-
CRN 45-5-1	40	3	230/460	286TSC	39	15 3/8	13 1/8	62	13 1/4	12 1/4	62	863	-	-	-	-
CRN 45-5	40	3	230/460	286TSC	39	15 3/8	13 1/8	62	13 1/4	12 1/4	62	863	-	-	-	-
CRN 45-6-2	50	3	230/460	324TSC	42 1/8	17	14 1/8	69 3/4	13 3/8	12 1/4	64 5/8	929	-	-	-	-
CRN 45-6	50	3	230/460	324TSC	42 1/8	17	14 1/8	69 3/4	13 3/8	12 1/4	64 5/8	929	-	-	-	-
CRN 45-7-2	50	3	230/460	324TSC	45 1/4	17	14 1/8	72 7/8	13 3/8	12 1/4	67 3/4	938	-	-	-	-
CRN 45-7	60	3	230/460	364TSC	45 1/4	19	15	75 7/8	15 1/4	13 1/4	71 1/4	1113	-	-	-	-
CRN 45-8-1	60	3	230/460	364TSC	48 3/8	19	15	79	15 1/4	13 1/4	74 3/8	1113	-	-	-	-

Weights based on pump with TEFC motor (see price list for individual weights)
All dimensions in inches unless otherwise noted.

JOB NAME	Red Hill Water Treatment		
JOB NO.	2008014	SHEET	1 OF 2
CALCULATED BY	HC	DATE	06/04/2009
CHECKED BY		DATE	

Objective: To calculate well pump capacity for Alternative 2

Q	=	16	mgd	Design capacity
	=	11104	gpm	
L	=	3000	ft	Approximate pipe length
H1	=	8	ft	Min water level at Red Hill PS
H2	=	420	ft	Site elevation
H3	=	42	ft	Air stripper height
H	=	454	ft	Approximate static head
g	=	32.2		
C	=	140		PVC pipe

Determine pipe size:
Per UFC 3-240-08FA, provide flushing velocity between 2.5 to 3.5 ft/s, with max velocity up to 10 ft/s

Use V = 4 ft/s
For Q = 11,104 GPM = 24.731 cfs
Required pipe A = Q/V = 6.1826 ft^2
D = sqrt (4A/pi()) = 2.806 ft = 33.668 in
Use D = 30 in
-> V = Q/A = 5.038 ft/s > 4 ft/s

Estimate dynamic headloss using Hazen-Willams equation:
$h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$ = 6.631 ft

Estimate minor head loss due to joints and valves: h=kV^2/(2g)

K value for entrance:	0.5	x	1	=	0.5
K value for strainer:	1	x	1	=	1
K value for bowl:	2.8	x	1	=	2.8
K value for 22.5-deg bends:	0.15	x	1	=	0.15
K value for 45-deg bends:	0.225	x	1	=	0.225
K value for 90-deg bends:	0.3	x	12	=	3.6
K valve for wyes::	1	x	1	=	1
K value for tees:	1.8	x	1	=	1.8
K valev for increases:	0.25	x	4	=	1
K value for gate valves:	0.19	x	1	=	0.19
K valve for butterfly valves:	0.46	x	2	=	0.92
K value for check valves:	2.2	x	2	=	4.4
K value for air release valves:	0.77	x	2	=	1.54
K valve for exit:	1	x	1	=	1
				sum(k)=	20.125

h= 7.932 ft

Total dynamic head (TDH):
TDH = Static Head + Dynamic head + Minor Head

= 454 + 6.631 + 7.9319

= 468.6 ft

Say 470 ft

Determine NPSH available (NPSHA)

REF: Pump characteristics and applications, by Michael W. Volk, CRC, 2005

$NPSHA = P + h_s - H_{VAP} - h_{fs} - \sum h_m$

P	= Absolute pressure on the surface of the liquid, ft
h_s	= Static head of the intake water surface above the eye of the impeller, ft
H_{VAP}	= Vapor pressure of fluid at max expected temperature, ft
h_{fs}	= Suction pipe friction loss, ft
$\sum h_m$	= Suction pipe minor loss, ft

cals:

P Min water level = 8 ft

Atmospheric pressure at sea level is approximate 14.7 psi = 34 ft

h_s Static head = 8 ft

H_{VAP} Vapor pressure, assume temp =90°F

H_{VAP} = 0.7 psi = 1.617 ft

h_{fs} Friction loss $h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$

suction pipe length L = 105 ft

suction pipe diameter D = 16 in

h_{fs} = 1.574 ft

$\sum h_m$ use $h = Kv^2/2g$ where v = Q/A = 8.856 ft/s

	K
entrance	0.5
strainer	1
bowl	2.8

$\sum h_m$ = 5.237 ft

-> NPSHA = 34 ft

Required NPSH from pump curve for pump operation at Q = 5,552 gpm

is 30 ft (Fairbanks Morse)

NPSHA = 34 ft > 30 ft okay

BEYLIK DRILLING & PUMP SERVICE, INC.

Serving the Water Industry for over 30 years

91-259A Olai Street, Kapolei, HI 96707 - Ph: (808) 682-5554 - Fax: (808) 682-5866

WATER WELL DRILLING - MONITORING WELLS - WELL AND PUMP REPAIR - TEST HOLES

Contractor's License No.: AC-21896

BUDGETARY PROPOSAL

July 21, 2009

HDR/Hawaii Pacific Engineers, Inc
1132 Bishop St Suite 1003
Honolulu, HI 96813-2830

Attn: Wendy Chen

Re: Budgetary Proposal to Replace Original Layne 24EHM-3 Stg SN:10563 – 66

Thank you for allowing us the opportunity to offer the following budgetary proposal for your review and consideration:

Red Hill Pumping Stations, Oahu

(1) Booster Pump(s)
- **1-** Layne 22GH – 3 Stg, 5,550 GPM @ 240' – 470' TDH Bowl Assy, 16" Column, 24T1624 Fabricated Head, US **450HP** VHS,TEFC Motor…….**Budgetary $249,150.00***
- **2-** Layne 22GH – 5 Stg, 5,550 GPM @ 240' – 650' TDH Bowl Assy, 16" Column, 24T1630 Fabricated Head, US **800HP** VHS WP-11 Motor…**Budgetary $338,250.00***

(1) Layne 22GH – 3 Stg, 5,550 GPM @ 240' TDH Bowl Assy, 16" Column, FSC1624 Fabricated Head, US **500HP** VHS, TEFC Motor……………………..…..**Budgetary $409,200.00***

(1) Layne 22GH – 6 Stg, 5,550 GPM @ 470' TDH Bowl Assy, 16" Column, FSC1630 Fabricated Head, US **900HP** VHS, WP-II Motor………………………**Budgetary $518,200.00***

(1) Layne 19DROHC - 5 Stg 5,550 GPM @ 650' TDH Bowl Assy, 16" Column, FSC1630 Fabricated Head, US **1250HP** Motor……………………………….…**Budgetary $615,450.00***

Estimated Lead Time for the above unit(s): 28-36 Weeks
Submittals (if hold for approval) 8-12 Weeks
Ocean Freight Lead Time 4-6 Weeks
Freight & Tax Not Included

If you have any questions regarding the items proposed above, please call me at 682-5554.

Very truly yours,

Toni Gonsalves
Estimator / Project Manager

TERMS AND CONDITIONS

LIABILITY OF CONTRACTOR: Contractor shall not be liable for any bodily injury, death or injury to or destruction of tangible property, except, as the same may have been caused by the negligence of Contractor. In no event shall Contractor be liable for any delays or special, indirect, incidental or consequential damages Purchaser agrees that the total limit of Contractor's liability (whether based on negligence, warranty, strict liability or otherwise) hereunder, shall not exceed the aggregate amount due Contractor for services rendered under this contract. All claims, including claims for negligence of any other cause whatsoever, shall be deemed waived unless made in writing and received by Contractor within one (1) year after Contractor's completion of work hereunder.

INSURANCE: Contractor shall provide worker's compensation insurance, public liability and property damage insurance covering its employees and operation Purchaser, at its option, may maintain such insurance as will protect it against claims out from the work.

PRICE ADJUSTMENT: Any cost estimates or time frames stated herein are subject to equitable adjustment in the event of differing or unforeseeable conditions, changes in applicable laws after the date of this contract, unforeseeable delays or difficulties caused by acts of God, Purchaser or any third parties. Prices of good acquired by Contractor from others shall be adjusted to reflect Contractor's price in effect at time of shipment. The price of Contractor's good will be adjusted to the price in effect at time of shipment in accordance with Contractor's current escalation policies or as specifically covered in this contract.

TERMS: Due upon Receipt. For extended projects, Contractor shall submit invoices on a monthly basis for any and all work completed and materials or equipment provided during the previous month. Past due invoices shall be subject to a delinquency charge of one and one-half percent (1-1/2%) per month (eighteen percent (18%) per annum) unless lower change is required under applicable law, in which case the lower rate shall apply. Purchaser agrees to pay all collection fees, attorneys' fees and cost incurred in the collection of any past due amounts arising out of this contract. Contractor shall have the right to immediately terminate this contract without further liability if Purchaser fails to make timely payment or otherwise materially breaches contract.

MATERIAL SHORTAGES AND COST INCREASES: If any portion of materials or equipment which Contractor is required to furnish becomes unavailable, either temporarily or permanently, through causes beyond the control and without the fault of Contractor, then in the case of temporary unavailability any completion time frames shall be extended for such period of time as Contractor shall be delayed by such above-described unavailability. And in the case of permanent unavailability Contractor shall be excused from the requirement of furnishing such material or equipment. Purchaser agrees to pay Contractor any increase in cost between the cost of the materials or equipment which becomes permanently unavailable and the cost of the closest substitute, which is then reasonably available.

DELAYS: If Contractor is delayed at any time in the progress of work by labor disputes, fire, unusual delays in transportation unavoidable casualties, weather, or any cause beyond Contractor's reasonable control, then any completion time frames shall be extended by a reasonable period of time, at least equal to the period of delay.

CHANGED CONDITIONS: The discovery of any hazardous waste, substances, pollutants contaminants, underground obstructions or utilities on or in the job-site which were not brought to the attention of Contractor prior to the date of this contract will constitute a materially different site condition entitling Contractor, at its sole discretion to immediately terminate this contract without further liability.

GUARANTEE AND LIABILITY: Contractor warrants that its labor supplied hereunder shall be free from defect and shall conform to the standards of care in effect in its industry at the time of performance of such labor for a period of <u>twelve (12) months after substantial completion of Contractor's work</u>. Contractor agrees, to the extent it is permitted, to pass on any warranties provided by the manufacturer of material and/or equipment furnished under this contract. Contractor itself provided no warranty, express, implied or otherwise, on any such materials or equipment. Contractor will not be responsible for work done material or equipment furnished or repairs or alterations made by others.

For any breach, hereunder, Contractor shall be liable only for the value of the installation work or, if it wrongfully fails to install, then its liability is limited to the difference between the contract price herein and the value of other similar installation work. If Contractor damages any materials or equipment furnished hereunder, Contractor shall only be liable for the value of such materials or equipment. Under no circumstances will Contractor be liable for consequential, special or indirect damages. Including without limitation any crop loss or damage to other equipment structure or property, nor for any other similar or dissimilar damages or losses whether due to delay, failure to furnish or install, delay in installation defective material or equipment, defective workmanship, defective installation, delay in replacing, nor for any cause or breach whatsoever. In any event, Contractor's total liability toward Purchaser for alleged faulty performance mentioned in this contract. THE ABOVE WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED INCLUDING BUT NOT LIMITED TO, WARRANTIES OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WHICH ARE HEREBY DISCLAIMED.

TITLE AND OWNERSHIP: In case of default on Purchaser's part, Contractor shall have the right to enter the premises upon which any material or equipment furnished herein have been installed an retake such goods not then paid for and pursue any further remedy provided by law, including recovery of attorney's fees and any deficiency to the maximum extent and in the matter provided by law. Such materials and equipment shall retain their character as personal property of Contractor until Contractor receives payment in full, regardless of their mode of attachment. Unless prior specific written instructions are received to the contrary, surplus and replaced materials and equipment resulting from repair of installation work shall become the property of Contractor.

DELIVERY: Shipment schedules and dates, expressed or implied, are contingent on normal conditions. Contractor will not be responsible for any delays in shipment or completion caused by factors beyond its control such as, but no limited to, suppliers' failures, accidents, work stoppages or operation of or changes in the law. Shipments will be made as promptly as Contractor's ability to obtain materials and/or equipment and scheduling will permit. No delay in shipments or contract will be made at Purchaser's additional cost. Any such change and/or time taken to supply engineering data or to approve drawings will automatically extend shipping schedules. Equipment will be shipped "knocked down" to the extent Contractor considers necessary, with small parts stripped from equipment and crated. On and after delivery to the carrier for transportation to the Purchaser's site, Purchaser shall be responsible fro all loss or damage to materials or equipment due to any cause, including but not limited to loss or damage resulting from casualty.

INDEMNIFICATION: Purchaser agrees to indemnify and hold Contractor, its directors, officers, stockholders, employees, agents and subcontractors, harmless from and against any and all claims, demands, causes or action (including third party claims, demands or causes of actions for contribution or indemnification), liability and costs (including g attorney's fees and other costs of defense) asserted and/or filed by Purchaser or any third party(ies), including without limitation Purchaser's employees, and arising out of or as a result of: (i) the presence of Contractor or its subcontractors at the job-site (ii) the work performed by Contractor or its subcontractors, or (iii) any negligent act or omission of Purchaser, its employees, agents, consultant or other Contractors or any person or entity under Purchaser's control: except to the extent that such claims, demands, causes of action, liabilities or costs are caused by the negligence of Contractor or its subcontractors.

INTERPRETATION: This contract shall be governed by and constructed in accordance with the laws of the state of the job-site location. In any term, provision or condition contained herein shall, to any extent, be invalid or unenforceable, pursuant to state law or otherwise, the remainder of the terms, provision and conditions herein (or the application of such term, provision or condition to persons or circumstances other that those in respect of which it is invalid or unenforceable) shall not be affected thereby, and each term, provision and condition of this contract shall be valid and enforceable to the fullest extent permitted by law.

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Beylik Drilling & Pump Service, Inc.
91-259A Olai Street
Kapolei, HI 96707
Ph: (808) 682-5554 Fax: (808) 682-5866
www.beylik.com

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Pump Data Sheet - Layne/Verti-Line

Company: Beylik Drilling & Pump Service   Red Hill
Name: Toni Gonsalves
Date: 7/22/2009

Pump:

Size: 22GH (6 stage)

Type: Vertical Turbine Synch speed: 1200 rpm	Speed: 1180 rpm Dia: 17 in
Curve:	Impeller:
Specific Speeds:	Ns: --- Nss: ---
Dimensions:	Suction: --- Discharge: 16 in
Vertical Turbine:	Bowl size: 21.5 in Max lateral: --- Thrust K factor: 44 lb/ft

Pump Limits:

Temperature: 150 °F Pressure: 350 psi g Sphere size: 1.42 in	Power: --- Eye area: 91.4 in²

Search Criteria:

Flow: 5550 US gpm   Head: 470 ft

Fluid:

Water SG: 1 Viscosity: 1.105 cP	Temperature: 60 °F Vapor pressure: 0.2563 psi a Atm pressure: 14.7 psi a
NPSHa: ---	

Motor:

Standard: NEMA Enclosure: TEFC	--- Speed: --- Frame: ---

Sizing criteria: Max Power on Design Curve

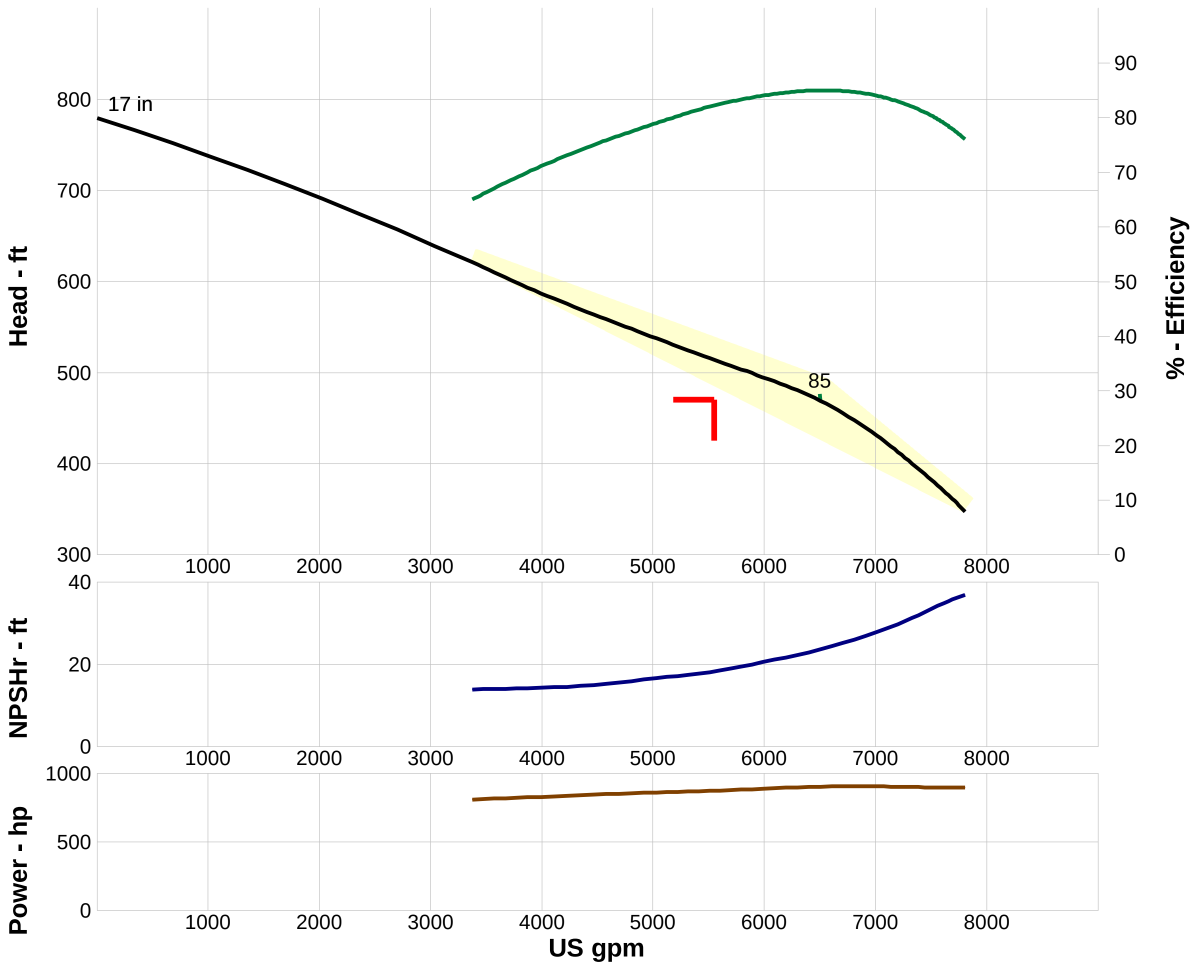
---- Data Point ----

Flow:	5550 US gpm
Head:	514 ft
Eff:	82.2%
Power:	876 hp
NPSHr:	18.4 ft

---- Design Curve ----

Shutoff head:	780 ft
Shutoff dP:	337 psi
Min flow:	---

BEP: 85% @ 6501 US gpm
NOL power:
908 hp @ 7008 US gpm



22-1/2 inch bell suction

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
6660	1180	457	84.7	907	25
5550	1180	514	82.2	876	18.4
4440	1180	565	74.8	847	15
3330	1180	---	---	---	---
2220	1180	---	---	---	---

Selected from catalog: Layne-Vertiline.60 Vers: 1

Subject: **Red Hill**
Date: 7/10/2009 12:09:08 PM Hawaiian Standard Time
From: brantw@earthlink.net
To: esiKAILUA@aol.com

Scotty,

For the 5 Stage 17H, the pump budget estimate is approx $98K. The motor for this pump will be 900 HP (we can not quite hold 800 with column losses and trim allowance). The budget on the motor (I assumed VHS WP-I, 2300 V) is $65K.

For the 7 Stage 17H, the pump budget estimate is approx $115K. The motor for this pump will be 1250 HP (we can not quite hold 800 with column losses and trim allowance). The budget on the motor (I assumed VHS WP-I, 2300 V) is $90K

For the 20" 5721, the pump and base will be about $75K. Motor will be approx $30K. This is for a Horizontal, WP-I motor. This is pretty price for a small motor...because this is such a low low speed. This will be a special motor. We may even have a hard time finding a motor this small...at this low low speed. As such, I am not super confident on the price. We could get burned with such an odd motor.

For the 24" 5721, the pump and base will be about $105K. Motor will be approx $35K. This is for a Horizontal, WP-I motor.

For the 20" 5722, the pump and base will be about $130K (This is a big pump). Motor will be approx $40K. This is for a Horizontal, WP-I motor.

Let me know what else you need on this one.

Thanks,
-Brant

Brant Williams, Regional Manager - Western US
Fairbanks Morse Pump Company
14850 Highway 4, Suite A - #327
Discovery Bay, CA 94505
559.269.3931 (Mobile)
925.265.2265 (Fax)

Pump Data Sheet - Fairbanks Morse Pump, 60 Hz

Company: Enginneered System Hawaii
Name: Paul Scott
Date: 7/20/2009

Fairbanks Morse
Pentair Water

Pump:

Size: 21H.4+ (4 stage)

Type: VERT.TURBINE
Synch speed: 1800 rpm

Speed: 1770 rpm
Dia: 11.6875 in

Curve:

Impeller:

Specific Speeds:

Ns: ---
Nss: ---

Dimensions:

Suction: 20.75 in
Discharge: 16 in

Vertical Turbine:

Bowl size: 19.6 in
Max lateral: 0.94 in
Thrust K factor: 28.5 lb/ft

Pump Limits:

Temperature: 150 °F
Pressure: 465 psi g
Sphere size: 1.62 in

Power: 1043 hp
Eye area: ---

Search Criteria:

Flow: 5550 US gpm

Head: 470 ft

Fluid:

Water
SG: 1
Viscosity: 1.105 cP
NPSHa: ---

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

Motor:

Standard: NEMA
Enclosure: TEFC

Speed: ---
Frame: ---

Sizing criteria: Max Power on Design Curve

---- Data Point ----

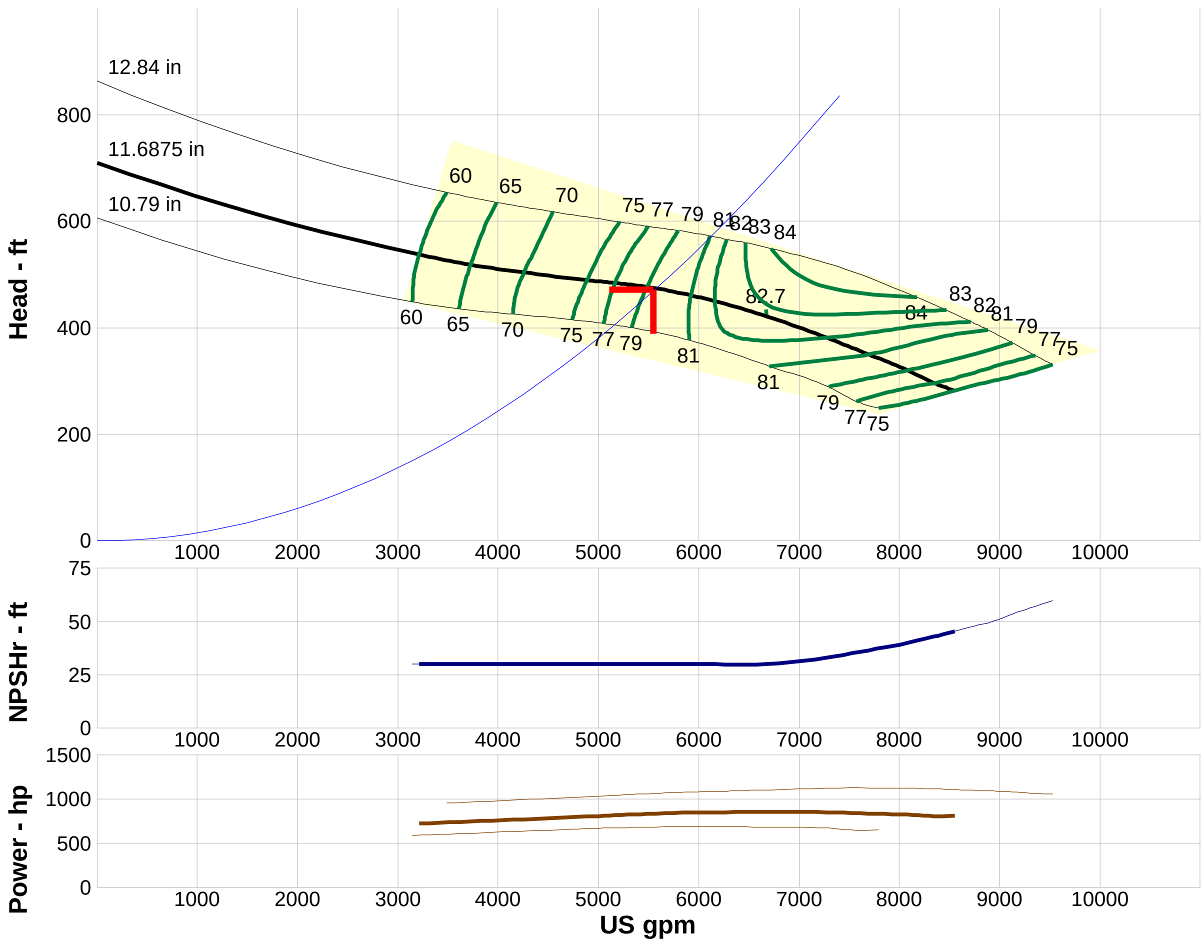
Flow: 5550 US gpm
Head: 474 ft
Eff: 79.3%
Power: 838 hp
NPSHr: 30 ft

---- Design Curve ----

Shutoff head: 710 ft
Shutoff dP: 307 psi
Min flow: ---
BEP: 82.7% @ 6673 US gpm
NOL power:
858 hp @ 6673 US gpm

-- Max Curve --

Max power:
1129 hp @ 7388 US gpm



Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
6660	1770	422	82.7	858	30.1
5550	1770	474	79.3	838	30
4440	1770	500	71.5	782	30
3330	1770	533	61.2	731	30
2220	1770	---	---	---	---

Selected from catalog: Fairbanks Morse Turbine.60 Vers: 3

JOB NAME	Red Hill Water Treatment			
JOB NO.	2008014	SHEET	1	OF 2
CALCULATED BY	HC	DATE	06/04/2009	
CHECKED BY		DATE		

Objective: To calculate well pump capacity for Alternative 3

Q	=	16	mgd	Design capacity
	=	11104	gpm	
L	=	6000	ft	Approximate pipe length
H1	=	8	ft	Min water level at Red Hill PS
H2	=	590	ft	Site elevation
H3	=	42	ft	Air stripper height
H	=	624	ft	Approximate static head
g	=	32.2		
C	=	140		

Determine pipe size:
Per UFC 3-240-08FA, provide flushing velocity between 2.5 to 3.5 ft/s, with max velocity up to 10 ft/s

Use V = 4 ft/s
For Q = 11,104 GPM = 24.731 cfs
Required pipe A = Q/V = 6.1826 ft^2
D = sqrt (4A/pi()) = 2.806 ft = 33.67 in
Use D = 30 in
-> V = Q/A = 5.038 ft/s > 4 ft/s

Find dynamic headloss using Hazen-Willams equation:
$h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$ = 13.26 ft

Find minor head loss due to joints and valves: h=kV^2/(2g)

K value for entrance:	0.5	x	1	=	0.5
K value for strainer:	1	x	1	=	1
K value for bowl:	2.8	x	1	=	2.8
K value for 22.5-deg bends:	0.15	x	1	=	0.15
K value for 45-deg bends:	0.225	x	1	=	0.225
K value for 90-deg bends:	0.3	x	12	=	3.6
K valve for wyes::	1	x	1	=	1
K value for tees:	1.8	x	1	=	1.8
K valev for increases:	0.25	x	4	=	1
K value for gate valves:	0.19	x	1	=	0.19
K valve for butterfly valves:	0.46	x	2	=	0.92
K value for check valves:	2.2	x	2	=	4.4
K value for air release valves:	0.77	x	2	=	1.54
K valve for exit:	1	x	1	=	1
					sum(k)= 20

h= 7.932 ft

Total dynamic head (TDH):
TDH = Static Head + Dynamic head + Minor Head

= 624 + 13.26 + 7.932
= 645.2 ft
Say 650 ft

Determine NPSH available (NPSHA)
REF: Pump characteristics and applications, by Michael W. Volk, CRC, 2005
NPSHA = P + h_s - H_{VAP} -h_{fs} - $\sum h_m$

P = Absolute pressure on the surface of the liquid, ft
h_s = Static head of the intake water surface above the eye of the impeller, ft
H_{VAP} = Vapor pressure of fluid at max expected temperature, ft
h_{fs} = Suction pipe friction loss, ft
$\sum h_m$ = Suction pipe minor loss, ft

cals:

P Min water level = 8 ft
Atmospheric pressure at sea level is approximate 14.7 psi = 34 ft
h_s Static head = 8 ft
H_{VAP} Vapor pressure, assume temp =90°F
H_{VAP} = 0.7 psi = 1.617 ft
h_{fs} Friction loss $h_f = 3.02LD^{(-1.167)}(V/C)^{1.85}$
suction pipe length L = 105 ft
suction pipe diameter D = 16 in
h_{fs} = 1.574 ft
$\sum h_m$ use $h = Kv^2/2g$ where v = Q/A = 8.856 ft/s

	K
entrance	0.5
strainer	1
bowl	2.8

$\sum h_m$ = 5.237 ft

-> NPSHA = 34 ft

Required NPSH from pump curve for pump operation at Q = 5,552 gpm
is 30 ft (Fairbanks Morse)

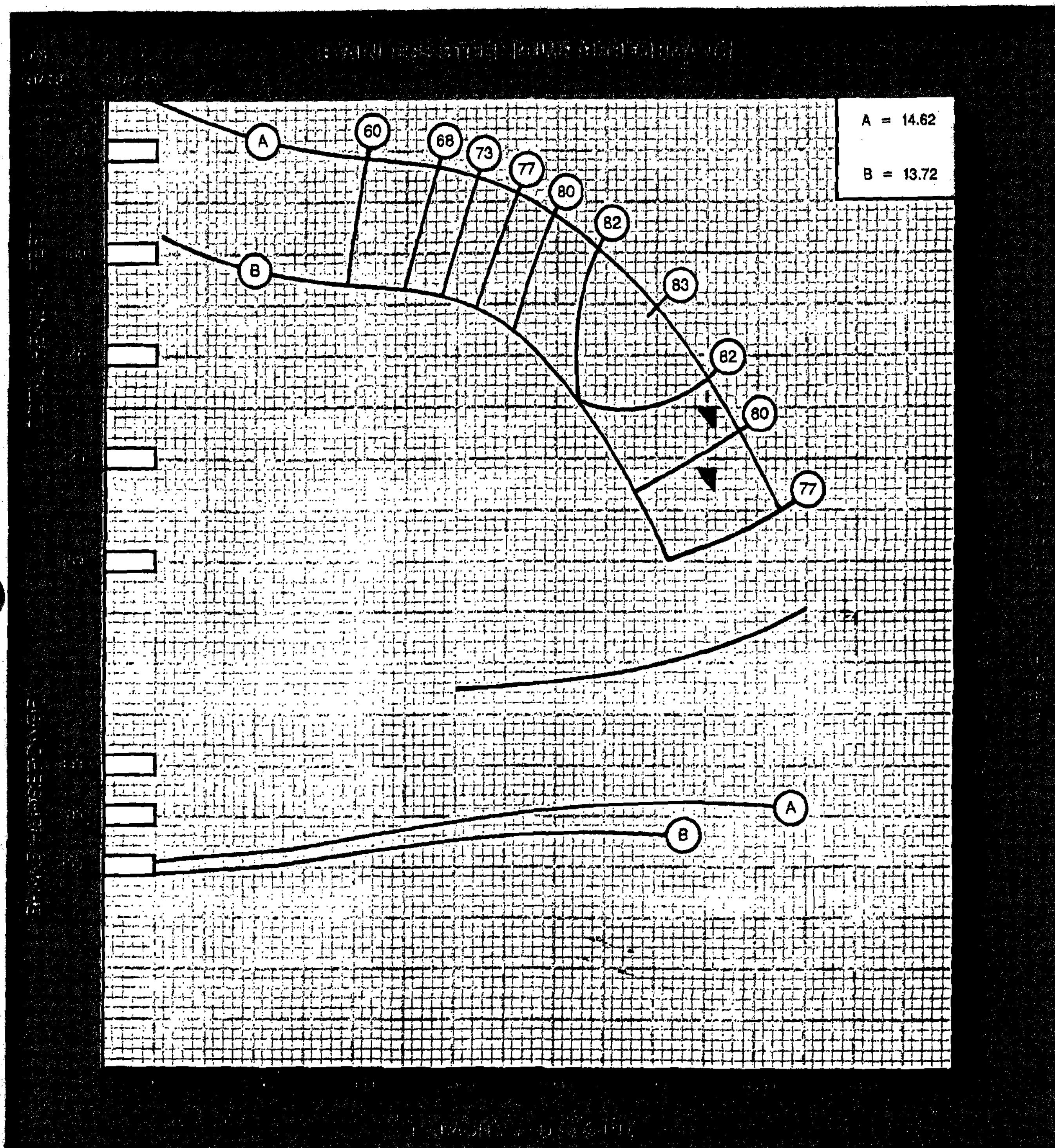
NPSHA = 34 > 30 ft okay

LAYNE & BOWLER
A DIVISION OF THE MARLEY COMPANY

No. Stages	Eff. Change	Thrust Factor
1	-2	
2	0	14
3		
4		

19DROHC 1770 R.P.M.

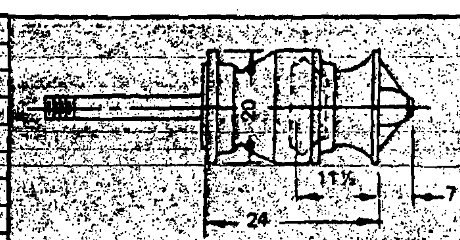
SINGLE STAGE LAB PERFORMANCE WITH STANDARD MATERIALS. EFFICIENCY SHOWN FOR 2 OR MORE STAGES. HORSE POWER SHOWN FOR ONE STAGE BASED ON 2 STAGE EFFICIENCY. CORRECTIONS SHOULD BE MADE FOR STAGES AND MATERIAL.



5 stg

4 stg

EYE AREA — SQ. IN.	= 64	IMPELLER WT. LBS.	= 75
WR² PER IMPELLER	= 9.6 LB.-FT.²	ONE STAGE WT. LBS.	= 790
MAX. SPHERE SIZE	= 1.125 in.	ADD'L STAGE WT. LBS.	= 370
MAX. NO. STD. STAGES	= 10	IMPELLER NUMBER	= 19DROHC
MAX. OPERATING P.S.I.	= 800	DISCH.	= FLANGED
STD. LATERAL	= 0.62 in.	SUCTION	= BELL
STD. SHAFT DIA.	= 2.937 in.		
MAX. SHAFT DIA.	= 2.937 in.		
MIN. SUBMERGENCE	= 38 in.	ADD 14" PER ADDITIONAL STAGE.	



Pump Data Sheet - Fairbanks Morse Pump, 60 Hz

Company: Enginneered System Hawaii
Name: Paul Scott
Date: 7/20/2009

Fairbanks Morse
Pentair Water

Pump:

Size: 21H.4+ (5 stage)

Type: VERT.TURBINE
Synch speed: 1800 rpm

Speed: 1770 rpm
Dia: 12.1875 in

Curve:

Impeller:

Specific Speeds:

Ns: ---
Nss: ---

Dimensions:

Suction: 20.75 in
Discharge: 16 in

Vertical Turbine:

Bowl size: 19.6 in
Max lateral: 0.94 in
Thrust K factor: 28.5 lb/ft

Pump Limits:

Temperature: 150 °F
Pressure: 465 psi g
Sphere size: 1.62 in

Power: 1043 hp
Eye area: ---

Search Criteria:

Flow: 5550 US gpm

Head: 650 ft

Fluid:

Water
SG: 1
Viscosity: 1.105 cP

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

NPSHa: ---

Motor:

Standard: NEMA
Enclosure: TEFC

Speed: ---
Frame: ---

Sizing criteria: Max Power on Design Curve

Pump Selection Warnings:

Design curve maximum power exceeds limit for the pump.

---- Data Point ----

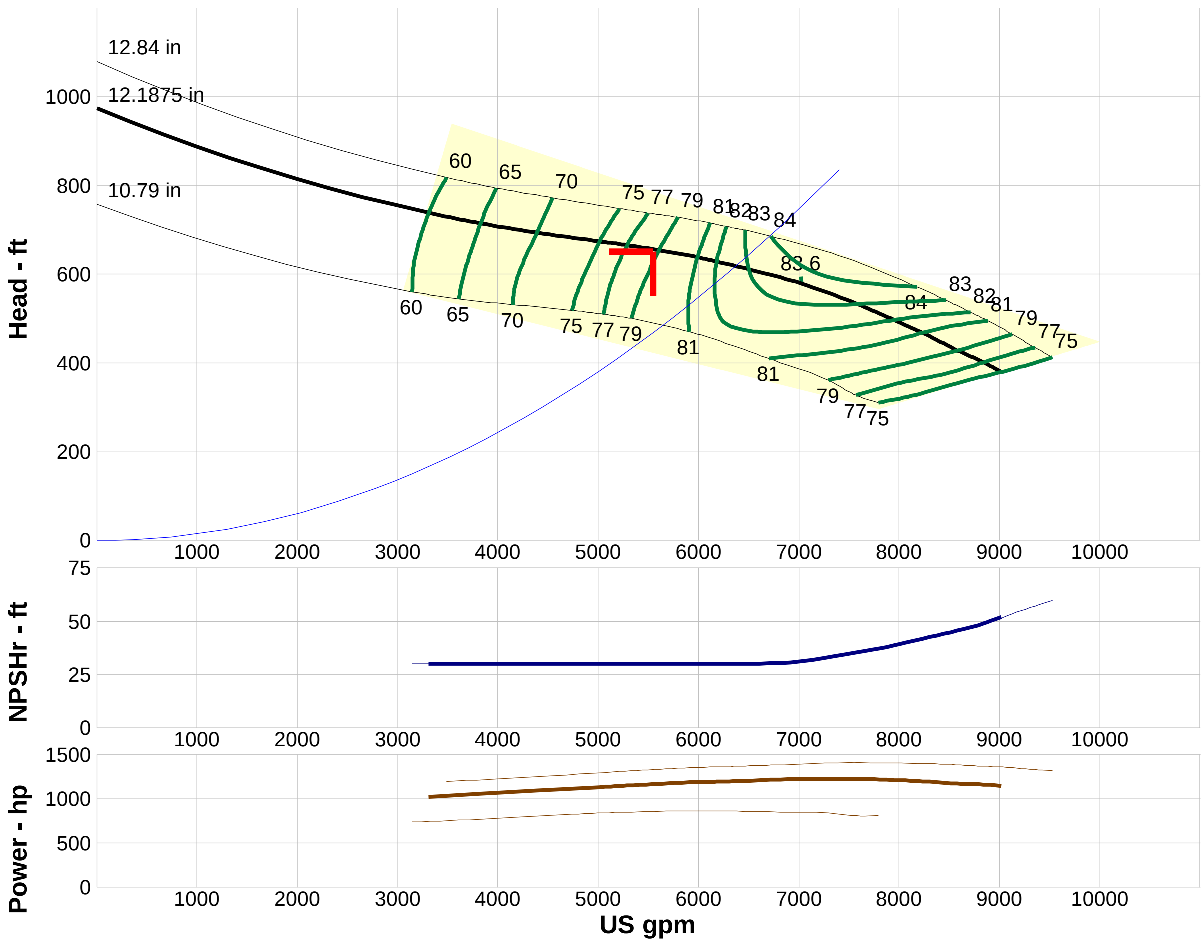
Flow: 5550 US gpm
Head: 657 ft
Eff: 78.7%
Power: 1169 hp
NPSHr: 30 ft

---- Design Curve ----

Shutoff head: 974 ft
Shutoff dP: 421 psi
Min flow: ---
BEP: 83.6% @ 7021 US gpm
NOL power:
1229 hp @ 7578 US gpm

-- Max Curve --

Max power:
1411 hp @ 7388 US gpm



Curve efficiencies are typical. For guaranteed values, contact Fairbanks Morse or your local distributor. Las eficiencias en curvas son típicas. Para valores garantizados contacte a Fairbanks Morse o a su distribuidor local.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
6660	1770	601	83.2	1215	30.5
5550	1770	657	78.7	1169	30
4440	1770	692	70.5	1101	30
3330	1770	737	60.3	1029	30
2220	1770	---	---	---	---

Appendix C

Cost Estimates

Red Hill Water Treatment Cost Estimation Summary

	Alternative 1	Alternative 2a	Alternative 2b	Alternative 3a	Alternative 3b
Capital Costs					
Site Work	$ 750,000	$ 610,000	$ 610,000	$ 510,000	$ 510,000
Packed Tower Aeration (PTA)	$ 3,200,000	$ 3,200,000	$ 3,200,000	$ 3,200,000	$ 3,200,000
Regen Thermal Oxidation for PTA	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000	$ 6,000,000
Granular Activated Carbon	$ 6,300,000	$ 6,100,000	$ 6,100,000	$ 6,100,000	$ 6,100,000
Mechanical Building	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000
GAC Storage Room	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Water Tank	N/A	$ 80,000	$ 80,000	$ 80,000	$ 80,000
Subtotal	**$ 16,550,000**	**$ 16,290,000**	**$ 16,290,000**	**$ 16,190,000**	**$ 16,190,000**
Vertical Turbine Pumps	N/A	$ 2,300,000	N/A	$ 2,700,000	N/A
Booster Pumps for Existing VTPs	N/A	N/A	$ 1,200,000	N/A	$ 1,500,000
Booster System	$ 90,000	N/A	N/A	N/A	N/A
Water Lines	$ 9,000,000	$ 3,300,000	$ 3,300,000	$ 5,600,000	$ 5,600,000
Electrical Work	$ 1,800,000	$ 3,400,000	$ 8,700,000	$ 9,500,000	$ 11,300,000
Instrumentation	$ 1,200,000	$ 1,400,000	$ 1,300,000	$ 1,400,000	$ 1,300,000
Subtotal	**$ 28,640,000**	**$ 26,690,000**	**$ 30,790,000**	**$ 35,390,000**	**$ 35,890,000**
Engineering and Construction Supervision @ 15%	$ 4,300,000	$ 4,100,000	$ 4,700,000	$ 5,400,000	$ 5,400,000
Subtotal	**$ 32,940,000**	**$ 30,790,000**	**$ 35,490,000**	**$ 40,790,000**	**$ 41,290,000**
Contingency @ 15%	$ 5,000,000	$ 4,700,000	$ 5,400,000	$ 6,200,000	$ 6,200,000
Subtotal	**$ 37,940,000**	**$ 35,490,000**	**$ 40,890,000**	**$ 46,990,000**	**$ 47,490,000**
Bond @ 2%	$ 760,000	$ 710,000	$ 820,000	$ 940,000	$ 950,000
Subtotal	**$ 38,700,000**	**$ 36,200,000**	**$ 41,710,000**	**$ 47,930,000**	**$ 48,440,000**
General Excise Tax @ 4.712%	$ 1,900,000	$ 1,800,000	$ 2,000,000	$ 2,300,000	$ 2,300,000
Total Capital Cost	**$ 40,600,000**	**$ 38,000,000**	**$ 43,710,000**	**$ 50,230,000**	**$ 50,740,000**
Total Capital Cost Rounded	**$ 41,000,000**	**$ 38,000,000**	**$ 44,000,000**	**$ 50,000,000**	**$ 51,000,000**
Annual O&M Costs					
Water Treatment Plant	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Water Treatment Plant Staff	$ 480,000	$ 480,000	$ 480,000	$ 480,000	$ 480,000
Activated Carbon Replacement	$ 4,700,000	$ 4,700,000	$ 4,700,000	$ 4,700,000	$ 4,700,000
Well Pumps and Transmission Pipe	$ 30,000	$ 20,000	$ 20,000	$ 30,000	$ 20,000
Electricity	$ 1,000,000	$ 1,400,000	$ 1,500,000	$ 1,700,000	$ 1,700,000
Total O&M	**$ 6,310,000**	**$ 6,700,000**	**$ 6,800,000**	**$ 7,010,000**	**$ 7,000,000**

Red Hill Water Treatment Life Cycle Cost Analsysis

Year	Alternative 1				Alternative 2a				Alternative 2b				Alternative 3a				Alternative 2b			
			Net Present Value =	$243,533,946			Net Present Value =	$250,790,248			Net Present Value =	$263,053,587			Net Present Value =	$274,616,725			Net Present Value =	$277,377,699
			Discount Factor =	2.8%			Discount Factor =	2.8%			Discount Factor =	2.8%			Discount Factor =	2.8%			Discount Factor =	2.8%
	Capital Cost	Equipt Replace-ment	Annual O&M	Total	Capital Cost	Equipt Replace-ment	Annual O&M	Total	Capital Cost	Equipt Replace-ment	Annual O&M	Total	Capital Cost	Equipt Replace-ment	Annual O&M	Total	Capital Cost	Equipt Replace-ment	Annual O&M	Total
0	40,600,000	0	6,310,000	46,910,000	38,000,000	0	6,700,000	44,700,000	43,710,000	0	6,800,000	50,510,000	50,230,000	0	7,010,000	57,240,000	50,740,000	0	7,000,000	57,740,000
1	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
2	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
3	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
4	0	1,800,000	6,310,000	8,110,000	0	90,000	6,700,000	6,790,000	0	1,890,000	6,800,000	8,690,000	0	0	7,010,000	7,010,000	0	1,800,000	7,000,000	8,800,000
5	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
6	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
7	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
8	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
9	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
10	0	9,290,000	6,310,000	15,600,000	0	11,500,000	6,700,000	18,200,000	0	10,400,000	6,800,000	17,200,000	0	11,900,000	7,010,000	18,910,000	0	10,700,000	7,000,000	17,700,000
11	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
12	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
13	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
14	0	1,800,000	6,310,000	8,110,000	0	90,000	6,700,000	6,790,000	0	1,890,000	6,800,000	8,690,000	0	0	7,010,000	7,010,000	0	1,800,000	7,000,000	8,800,000
15	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
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17	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
18	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
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20	0	9,290,000	6,310,000	15,600,000	0	11,500,000	6,700,000	18,200,000	0	10,400,000	6,800,000	17,200,000	0	11,900,000	7,010,000	18,910,000	0	10,700,000	7,000,000	17,700,000
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33	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
34	0	1,800,000	6,310,000	8,110,000	0	90,000	6,700,000	6,790,000	0	1,890,000	6,800,000	8,690,000	0	0	7,010,000	7,010,000	0	1,800,000	7,000,000	8,800,000
35	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
36	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
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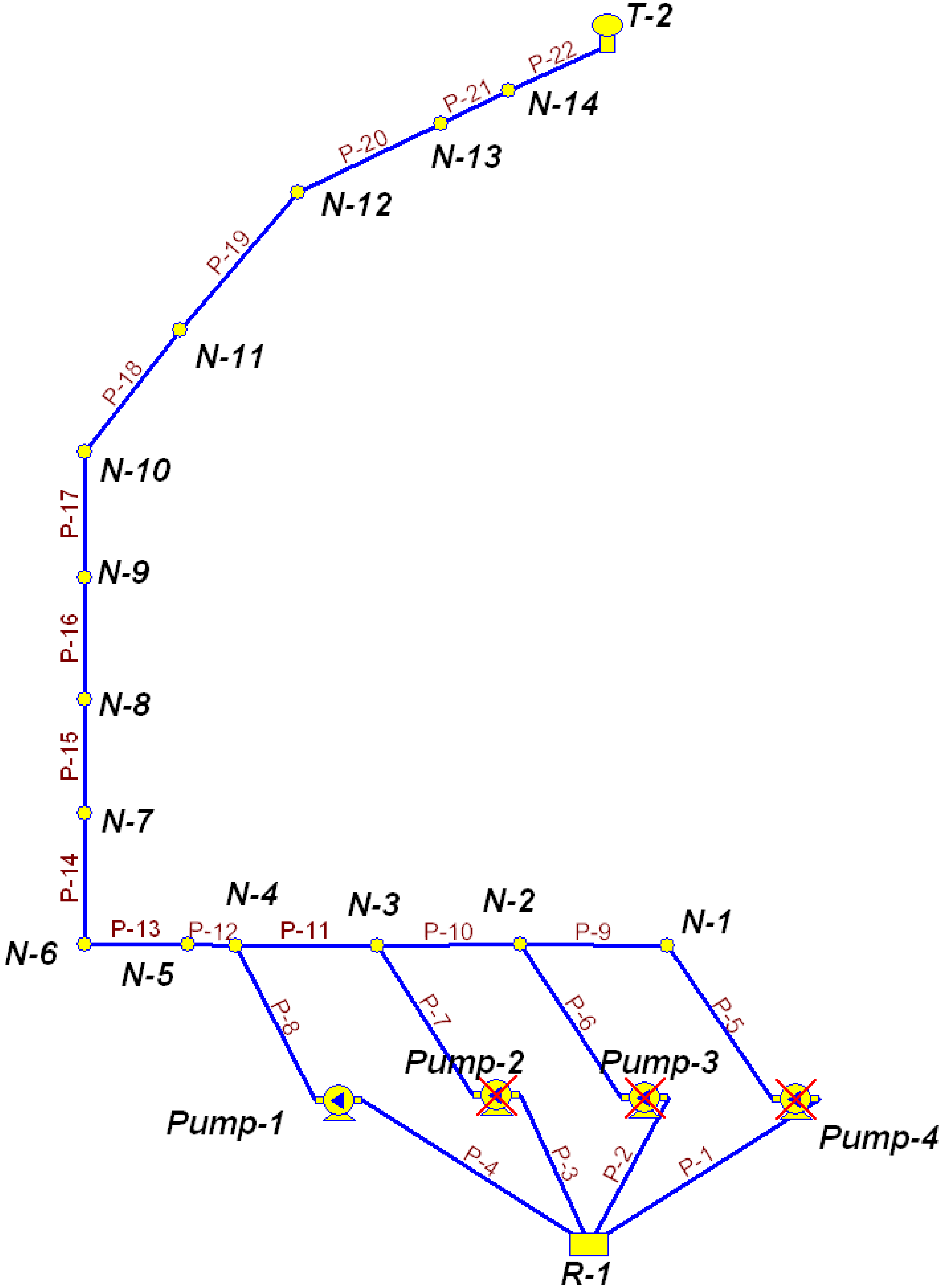
44	0	1,800,000	6,310,000	8,110,000	0	90,000	6,700,000	6,790,000	0	1,890,000	6,800,000	8,690,000	0	0	7,010,000	7,010,000	0	1,800,000	7,000,000	8,800,000
45	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
46	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
47	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
48	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
49	0	0	6,310,000	6,310,000	0	0	6,700,000	6,700,000	0	0	6,800,000	6,800,000	0	0	7,010,000	7,010,000	0	0	7,000,000	7,000,000
50	40,600,000	0	6,310,000	46,910,000	38,000,000	0	6,700,000	44,700,000	43,710,000	0	6,800,000	50,510,000	50,230,000	0	7,010,000	57,240,000	50,740,000	0	7,000,000	57,740,000

Appendix D

KYPIPE Calculations



Red Hill Water Treatment - Existing

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* * * * * * * * * * *   K Y P I P E 4   * * * * * * * * * * *
*                                                           *
*             Pipe Network Modeling Software                *
*                                                           *
*               Copyrighted by KYPIPE LLC                   *
*                 Version 4 - April 2008                    *
*                                                           *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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Date & Time: Tue Jul 14 14:45:42 2009

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POSTPROCESSOR RESULTS FILENAME --- P:\2008\2008014\KYPipe\Red_Hill.RS2

```
***********************************************
 S U M M A R Y   O F   O R I G I N A L   D A T A
***********************************************
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U N I T S   S P E C I F I E D

FLOWRATE .... = gallons/minute
HEAD (HGL) .... = feet
PRESSURE .... = psig

P I P E L I N E   D A T A

STATUS CODE: XX -CLOSED PIPE   CV -CHECK VALVE

P I P E N A M E	NODE NAMES #1	#2	LENGTH (ft)	DIAMETER (in)	ROUGHNESS COEFF.	MINOR LOSS COEFF.
P-1	R-1	I-Pump-4	108.84	16.00	130.0000	4.30
P-2	R-1	I-Pump-3	108.84	16.00	130.0000	4.30
P-3	R-1	I-Pump-2	108.84	16.00	130.0000	4.30
P-4	R-1	I-Pump-1	108.84	16.00	130.0000	4.30
P-5	O-Pump-4	N-1	11.59	16.00	130.0000	4.62
P-6	O-Pump-3	N-2	11.59	16.00	130.0000	4.62
P-7	O-Pump-2	N-3	11.59	16.00	130.0000	4.62
P-8	O-Pump-1	N-4	11.59	16.00	130.0000	4.62
P-9	N-1	N-2	8.00	16.00	130.0000	0.25
P-10	N-2	N-3	8.00	18.00	130.0000	0.25
P-11	N-3	N-4	8.00	20.00	130.0000	0.25
P-12	N-4	N-5	3.67	24.00	130.0000	1.80
P-13	N-5	N-6	17.33	30.00	130.0000	2.05
P-14	N-6	N-7	28.40	30.00	130.0000	0.70
P-15	N-7	N-8	22.50	30.00	130.0000	0.62
P-16	N-8	N-9	10.00	30.00	130.0000	0.25
P-17	N-9	N-10	7.00	30.00	130.0000	0.44
P-18	N-10	N-11	5440.00	30.00	130.0000	0.54
P-19	N-11	N-12	2515.00	30.00	130.0000	0.00
P-20	N-12	N-13	100.00	24.00	130.0000	0.65
P-21	N-13	N-14	5445.00	30.00	130.0000	8.76
P-22	N-14	T-2	30.00	24.00	130.0000	8.86

P U M P/L O S S   E L E M E N T   D A T A

THERE IS A PUMP AT NODE   Pump-1; USEFUL POWER =   400.00 (Efficiency = 70.00%)

THERE IS A PUMP AT NODE   Pump-2; USEFUL POWER =   400.00 (Efficiency = 70.00%)

THERE IS A PUMP AT NODE   Pump-3; USEFUL POWER =   400.00 (Efficiency = 70.00%)

THERE IS A PUMP AT NODE   Pump-4; USEFUL POWER =   400.00 (Efficiency = 70.00%)

N O D E   D A T A

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	JUNCTION ELEVATION (ft)	EXTERNAL GRADE (ft)
N-1		0.00	0.00	
N-2		0.00	0.00	
N-3		0.00	0.00	
N-4		0.00	0.00	
N-5		0.00	0.00	
N-6		0.00	0.00	
N-7		0.00	0.00	
N-8		0.00	0.00	
N-9		0.00	0.00	
N-10		0.00	0.00	
N-11		0.00	0.00	
N-12		0.00	0.00	
N-13		0.00	0.00	
N-14		0.00	0.00	
I-Pump-1		0.00	0.00	
I-Pump-2		0.00	0.00	
I-Pump-3		0.00	0.00	
I-Pump-4		0.00	0.00	
R-1		----	-10.00	8.00
T-2		----	140.00	165.00
O-Pump-4		0.00	0.00	
O-Pump-3		0.00	0.00	
O-Pump-2		0.00	0.00	
O-Pump-1		0.00	0.00	

O U T P U T   O P T I O N   D A T A

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT

MAXIMUM AND MINIMUM PRESSURES = 1
MAXIMUM AND MINIMUM VELOCITIES = 5
MAXIMUM AND MINIMUM HEAD LOSS/1000 = 5

S Y S T E M   C O N F I G U R A T I O N

NUMBER OF PIPES ....(p) = 22
NUMBER OF END NODES ....(j) = 18
NUMBER OF PRIMARY LOOPS ....(l) = 3
NUMBER OF SUPPLY NODES ....(f) = 2
NUMBER OF SUPPLY ZONES ....(z) = 1

Case: 0

RESULTS OBTAINED AFTER 8 TRIALS: ACCURACY = 0.00083

S I M U L A T I O N   D E S C R I P T I O N   (L A B E L)

P I P E L I N E   R E S U L T S

STATUS CODE: XX -CLOSED PIPE   CV -CHECK VALVE

PIPE NAME	NODE NUMBERS #1	#2	FLOWRATE (gpm)	HEAD LOSS (ft)	MINOR LOSS (ft)	LINE VELO. (ft/s)	HL+ML/ 1000 (ft/ft)	HL/ 1000 (ft/ft)
P-1	R-1	I-Pump-4	0.00	0.00	0.00	0.00	0.00	0.00
P-2	R-1	I-Pump-3	0.00	0.00	0.00	0.00	0.00	0.00
P-3	R-1	I-Pump-2	0.00	0.00	0.00	0.00	0.00	0.00
P-4	R-1	I-Pump-1	7668.18	2.96	9.99	12.24	119.00	27.17
P-5	O-Pump-4	N-1	0.00	0.00	0.00	0.00	0.00	0.00

P-6	O-Pump-3	N-2	0.00	0.00	0.00	0.00	0.00	0.00
P-7	O-Pump-2	N-3	0.00	0.00	0.00	0.00	0.00	0.00
P-8	O-Pump-1	N-4	7668.18	0.31	10.74	12.24	953.68	27.17
P-9	N-1	N-2	0.00	0.00	0.00	0.00	0.00	0.00
P-10	N-2	N-3	0.00	0.00	0.00	0.00	0.00	0.00
P-11	N-3	N-4	0.00	0.00	0.00	0.00	0.00	0.00
P-12	N-4	N-5	7668.18	0.01	0.83	5.44	228.95	3.77
P-13	N-5	N-6	7668.18	0.02	0.39	3.48	23.52	1.27
P-14	N-6	N-7	7668.18	0.04	0.13	3.48	5.91	1.27
P-15	N-7	N-8	7668.18	0.03	0.12	3.48	6.45	1.27
P-16	N-8	N-9	7668.18	0.01	0.05	3.48	5.97	1.27
P-17	N-9	N-10	7668.18	0.01	0.08	3.48	13.09	1.27
P-18	N-10	N-11	7668.18	6.92	0.10	3.48	1.29	1.27
P-19	N-11	N-12	7668.18	3.20	0.00	3.48	1.27	1.27
P-20	N-12	N-13	7668.18	0.38	0.30	5.44	6.76	3.77
P-21	N-13	N-14	7668.18	6.93	1.65	3.48	1.57	1.27
P-22	N-14	T-2	7668.18	0.11	4.07	5.44	139.37	3.77

P U M P/L O S S   E L E M E N T   R E S U L T S

NAME	FLOWRATE (gpm)	INLET HEAD (ft)	OUTLET HEAD (ft)	PUMP HEAD (ft)	EFFIC-ENCY (%)	USEFUL POWER (Hp)	INCREMTL COST ($)	TOTAL COST ($)	#PUMPS PARALLEL	#PUMPS SERIES	NPSH Avail. (ft)
Pump-1	7668.18	-4.95	201.42	206.4	----	-----	---	----	**	**	25.9

Device "Pump-2" is closed
Device "Pump-3" is closed
Device "Pump-4" is closed

N O D E   R E S U L T S

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	HYDRAULIC GRADE (ft)	NODE ELEVATION (ft)	PRESSURE HEAD (ft)	NODE PRESSURE (psi)
N-1		0.00	190.37			
N-2		0.00	190.37			
N-3		0.00	190.37			
N-4		0.00	190.37			
N-5		0.00	189.53			
N-6		0.00	189.12			
N-7		0.00	188.95			
N-8		0.00	188.81			
N-9		0.00	188.75			
N-10		0.00	188.66			
N-11		0.00	181.63			
N-12		0.00	178.43			
N-13		0.00	177.76			
N-14		0.00	169.18			
I-Pump-1		0.00	-4.95			
I-Pump-2		0.00	8.00			
I-Pump-3		0.00	8.00			
I-Pump-4		0.00	8.00			
R-1		----	8.00	-10.00	18.00	7.80
T-2		----	165.00	140.00	25.00	10.83
O-Pump-4		0.00	190.37			
O-Pump-3		0.00	190.37			
O-Pump-2		0.00	190.37			
O-Pump-1		0.00	201.42			

M A X I M U M   A N D   M I N I M U M   V A L U E S

P R E S S U R E S

JUNCTION NUMBER	MAXIMUM PRESSURES (psi)	JUNCTION NUMBER	MINIMUM PRESSURES (psi)
T-2	10.83	R-1	7.80

V E L O C I T I E S

PIPE NUMBER	MAXIMUM VELOCITY (ft/s)	PIPE NUMBER	MINIMUM VELOCITY (ft/s)
P-4	12.24	P-13	3.48
P-8	12.24	P-14	3.48
P-12	5.44	P-15	3.48
P-20	5.44	P-16	3.48
P-22	5.44	P-17	3.48

H L + M L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL+ML/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL+ML/1000 (ft/ft)
P-8	953.68	P-19	1.27
P-12	228.95	P-18	1.29
P-22	139.37	P-21	1.57
P-4	119.00	P-14	5.91
P-13	23.52	P-16	5.97

H L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL/1000 (ft/ft)
P-4	27.17	P-13	1.27
P-8	27.17	P-15	1.27
P-20	3.77	P-16	1.27
P-22	3.77	P-17	1.27
P-12	3.77	P-14	1.27

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

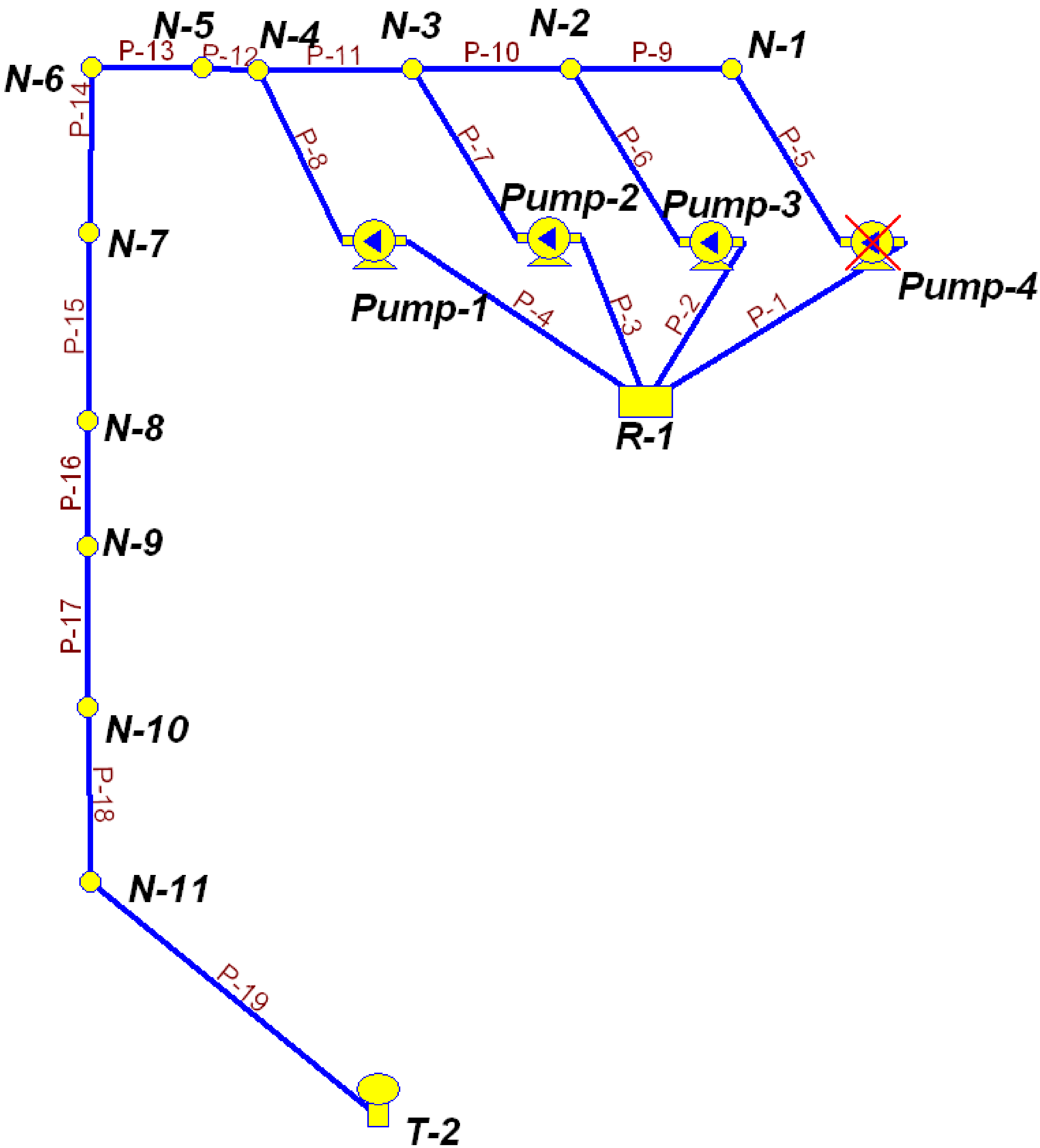
(+) INFLOWS INTO THE SYSTEM FROM SUPPLY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO SUPPLY NODES

NODE NAME	FLOWRATE (gpm)	NODE TITLE
R-1	7668.18	
T-2	-7668.18	

NET SYSTEM INFLOW = 7668.18
NET SYSTEM OUTFLOW = -7668.18
NET SYSTEM DEMAND = 0.00

***** HYDRAULIC ANALYSIS COMPLETED *****

Red Hill Water Treatment - Alt 2 - Exist Pumps



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* * * * * * * * * *   K Y P I P E 4   * * * * * * * * * *
*                                                         *
*            Pipe Network Modeling Software               *
*                                                         *
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*                                                         *
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Date & Time: Tue Jul 14 14:48:28 2009

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TABULATED OUTPUT FILENAME -------- P:\2008\2008014\KYPipe\Red_Hill.OT2
POSTPROCESSOR RESULTS FILENAME --- P:\2008\2008014\KYPipe\Red_Hill.RS2

****
S U M M A R Y   O F   O R I G I N A L   D A T A
****

U N I T S   S P E C I F I E D

FLOWRATE .... = gallons/minute
HEAD (HGL) .... = feet
PRESSURE .... = psig

P I P E L I N E   D A T A

STATUS CODE: XX -CLOSED PIPE CV -CHECK VALVE

P I P E N A M E	NODE NAMES #1	#2	LENGTH (ft)	DIAMETER (in)	ROUGHNESS COEFF.	MINOR LOSS COEFF.
P-1	R-1	I-Pump-4	108.84	16.00	130.0000	4.30
P-2	R-1	I-Pump-3	108.84	16.00	130.0000	4.30
P-3	R-1	I-Pump-2	108.84	16.00	130.0000	4.30
P-4	R-1	I-Pump-1	108.84	16.00	130.0000	4.30
P-5	O-Pump-4	N-1	11.59	16.00	130.0000	4.62
P-6	O-Pump-3	N-2	11.59	16.00	130.0000	4.62
P-7	O-Pump-2	N-3	11.59	16.00	130.0000	4.62
P-8	O-Pump-1	N-4	11.59	16.00	130.0000	4.62
P-9	N-1	N-2	8.00	16.00	130.0000	0.25
P-10	N-2	N-3	8.00	18.00	130.0000	0.25
P-11	N-3	N-4	8.00	20.00	130.0000	0.25
P-12	N-4	N-5	3.67	24.00	130.0000	1.80
P-13	N-5	N-6	17.33	30.00	130.0000	2.05
P-14	N-6	N-7	200.00	30.00	130.0000	2.40
P-15	N-7	N-8	130.00	30.00	130.0000	0.22
P-16	N-8	N-9	670.00	30.00	130.0000	0.00
P-17	N-9	N-10	476.00	30.00	130.0000	0.15
P-18	N-10	N-11	519.00	30.00	130.0000	0.00
P-19	N-11	T-2	750.00	30.00	130.0000	4.83

P U M P/L O S S   E L E M E N T   D A T A

THERE IS A PUMP AT NODE Pump-1; USEFUL POWER = 400.00 (Efficiency = 70.00%)

THERE IS A PUMP AT NODE Pump-2; USEFUL POWER = 400.00 (Efficiency = 70.00%)

THERE IS A PUMP AT NODE Pump-3; USEFUL POWER = 400.00 (Efficiency = 70.00%)

THERE IS A PUMP AT NODE Pump-4; USEFUL POWER = 400.00 (Efficiency = 70.00%)

N O D E   D A T A

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	JUNCTION ELEVATION (ft)	EXTERNAL GRADE (ft)
N-1		0.00	0.00	
N-2		0.00	0.00	
N-3		0.00	0.00	
N-4		0.00	0.00	
N-5		0.00	0.00	
N-6		0.00	0.00	
N-7		0.00	0.00	
N-8		0.00	0.00	
N-9		0.00	0.00	
N-10		0.00	0.00	
N-11		0.00	0.00	
I-Pump-1		0.00	0.00	
I-Pump-2		0.00	0.00	
I-Pump-3		0.00	0.00	
I-Pump-4		0.00	0.00	
R-1		----	-10.00	8.00
T-2		----	420.00	462.00
O-Pump-4		0.00	0.00	
O-Pump-3		0.00	0.00	
O-Pump-2		0.00	0.00	
O-Pump-1		0.00	0.00	

O U T P U T   O P T I O N   D A T A

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT
MAXIMUM AND MINIMUM PRESSURES = 1
MAXIMUM AND MINIMUM VELOCITIES = 5
MAXIMUM AND MINIMUM HEAD LOSS/1000 = 5

S Y S T E M   C O N F I G U R A T I O N

NUMBER OF PIPES ....(p) = 19
NUMBER OF END NODES ....(j) = 15
NUMBER OF PRIMARY LOOPS ....(l) = 3
NUMBER OF SUPPLY NODES ....(f) = 2
NUMBER OF SUPPLY ZONES ....(z) = 1

Case: 0

RESULTS OBTAINED AFTER 7 TRIALS: ACCURACY = 0.00326

S I M U L A T I O N   D E S C R I P T I O N   (L A B E L)

P I P E L I N E   R E S U L T S

STATUS CODE: XX -CLOSED PIPE   CV -CHECK VALVE

PIPE NAME	NODE NUMBERS #1	#2	FLOWRATE (gpm)	HEAD LOSS (ft)	MINOR LOSS (ft)	LINE VELO. (ft/s)	HL+ML/1000 (ft/ft)	HL/1000 (ft/ft)
P-1	R-1	I-Pump-4	0.00	0.00	0.00	0.00	0.00	0.00
P-2	R-1	I-Pump-3	3370.26	0.65	1.93	5.38	23.67	5.93
P-3	R-1	I-Pump-2	3370.94	0.65	1.93	5.38	23.68	5.93
P-4	R-1	I-Pump-1	3372.64	0.65	1.93	5.38	23.70	5.94
P-5	O-Pump-4	N-1	0.00	0.00	0.00	0.00	0.00	0.00
P-6	O-Pump-3	N-2	3370.26	0.07	2.07	5.38	184.90	5.93
P-7	O-Pump-2	N-3	3370.94	0.07	2.08	5.38	184.98	5.93
P-8	O-Pump-1	N-4	3372.64	0.07	2.08	5.38	185.16	5.94
P-9	N-1	N-2	0.00	0.00	0.00	0.00	0.00	0.00
P-10	N-2	N-3	3370.26	0.03	0.07	4.25	12.10	3.34
P-11	N-3	N-4	6741.20	0.06	0.18	6.88	30.21	7.22

P-12	N-4	N-5	10113.84	0.02	1.44	7.17	398.02	6.30
P-13	N-5	N-6	10113.84	0.04	0.67	4.59	40.82	2.12
P-14	N-6	N-7	10113.84	0.42	0.79	4.59	6.05	2.12
P-15	N-7	N-8	10113.84	0.28	0.07	4.59	2.68	2.12
P-16	N-8	N-9	10113.84	1.42	0.00	4.59	2.12	2.12
P-17	N-9	N-10	10113.84	1.01	0.05	4.59	2.23	2.12
P-18	N-10	N-11	10113.84	1.10	0.00	4.59	2.12	2.12
P-19	N-11	T-2	10113.84	1.59	1.58	4.59	4.23	2.12

P U M P/L O S S   E L E M E N T   R E S U L T S

NAME	FLOWRATE (gpm)	INLET HEAD (ft)	OUTLET HEAD (ft)	PUMP HEAD (ft)	EFFIC-ENCY (%)	USEFUL POWER (Hp)	INCREMTL COST ($)	TOTAL COST ($)	#PUMPS PARALLEL	#PUMPS SERIES	NPSH Avail. (ft)
Pump-1	3372.64	5.42	474.64	469.2	----	-----	---	----	**	**	38.2
Pump-2	3370.94	5.42	474.88	469.5	----	-----	---	----	**	**	38.2
Pump-3	3370.26	5.42	474.97	469.5	----	-----	---	----	**	**	38.2

Device "Pump-4" is closed

N O D E   R E S U L T S

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	HYDRAULIC GRADE (ft)	NODE ELEVATION (ft)	PRESSURE HEAD (ft)	NODE PRESSURE (psi)
N-1		0.00	472.83			
N-2		0.00	472.83			
N-3		0.00	472.73			
N-4		0.00	472.49			
N-5		0.00	471.03			
N-6		0.00	470.32			
N-7		0.00	469.11			
N-8		0.00	468.76			
N-9		0.00	467.34			
N-10		0.00	466.28			
N-11		0.00	465.17			
I-Pump-1		0.00	5.42			
I-Pump-2		0.00	5.42			
I-Pump-3		0.00	5.42			
I-Pump-4		0.00	8.00			
R-1		----	8.00	-10.00	18.00	7.80
T-2		----	462.00	420.00	42.00	18.20
O-Pump-4		0.00	472.83			
O-Pump-3		0.00	474.97			
O-Pump-2		0.00	474.88			
O-Pump-1		0.00	474.64			

M A X I M U M   A N D   M I N I M U M   V A L U E S

P R E S S U R E S

JUNCTION NUMBER	MAXIMUM PRESSURES (psi)	JUNCTION NUMBER	MINIMUM PRESSURES (psi)
T-2	18.20	R-1	7.80

V E L O C I T I E S

PIPE NUMBER	MAXIMUM VELOCITY (ft/s)	PIPE NUMBER	MINIMUM VELOCITY (ft/s)
P-12	7.17	P-10	4.25
P-11	6.88	P-13	4.59
P-4	5.38	P-14	4.59
P-8	5.38	P-15	4.59
P-3	5.38	P-16	4.59

H L + M L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL+ML/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL+ML/1000 (ft/ft)
P-12	398.02	P-16	2.12
P-8	185.16	P-18	2.12
P-7	184.98	P-17	2.23
P-6	184.90	P-15	2.68
P-13	40.82	P-19	4.23

H L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL/1000 (ft/ft)
P-11	7.22	P-13	2.12
P-12	6.30	P-16	2.12
P-8	5.94	P-17	2.12
P-4	5.94	P-14	2.12
P-3	5.93	P-15	2.12

S U M M A R Y   O F   I N F L O W S   A N D   O U T F L O W S

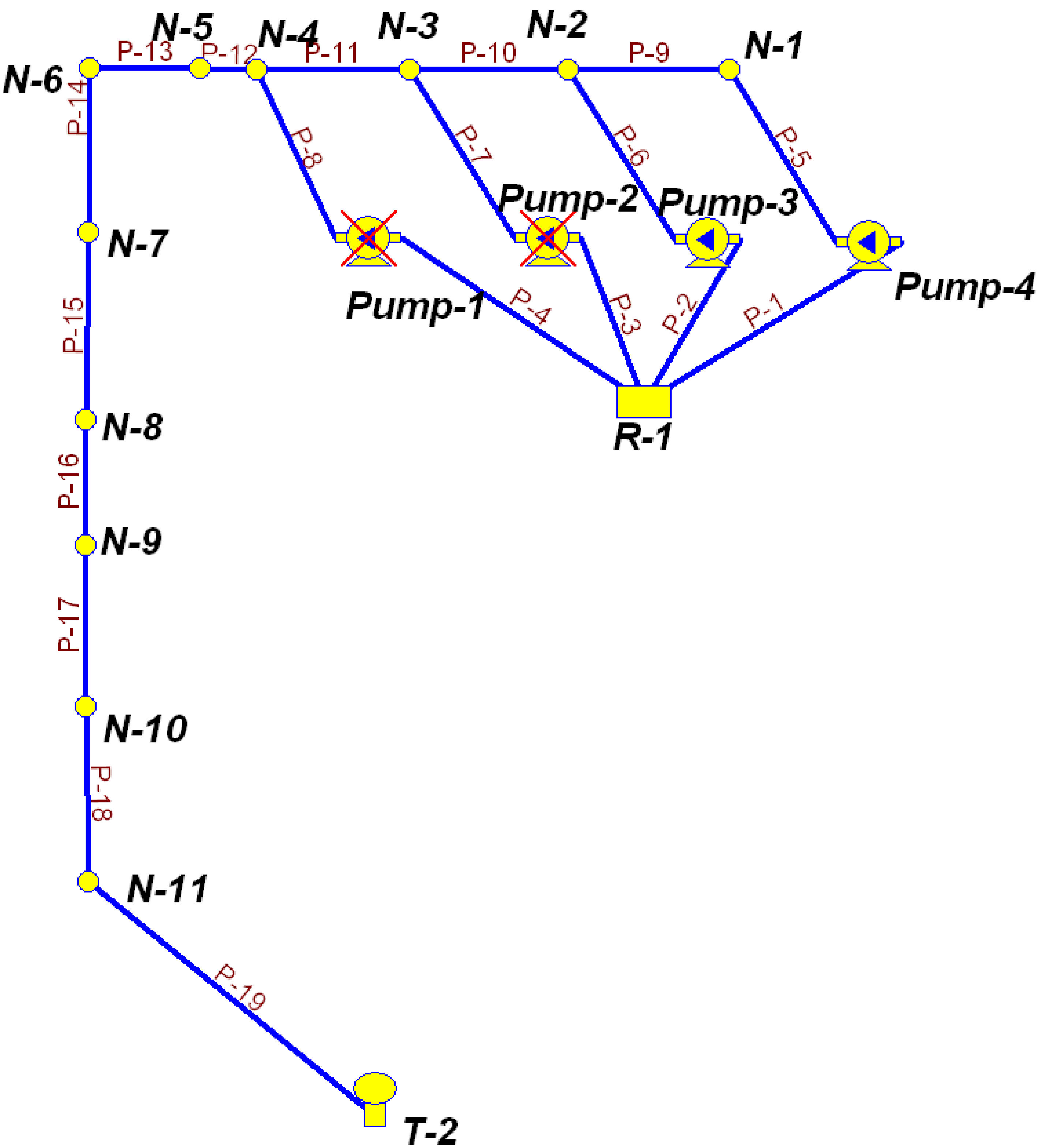
(+) INFLOWS INTO THE SYSTEM FROM SUPPLY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO SUPPLY NODES

NODE NAME	FLOWRATE (gpm)	NODE TITLE
R-1	10113.84	
T-2	-10113.84	

NET SYSTEM INFLOW = 10113.84
NET SYSTEM OUTFLOW = -10113.84
NET SYSTEM DEMAND = 0.00

***** HYDRAULIC ANALYSIS COMPLETED *****

Red Hill Water Treatment - Alt 2 - New Pumps



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* * * * * * * * * * *   K Y P I P E 4   * * * * * * * * * * *
*                                                           *
*              Pipe Network Modeling Software               *
*                                                           *
*                Copyrighted by KYPIPE LLC                  *
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*                                                           *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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Date & Time: Mon Jul 20 14:58:55 2009

INPUT DATA FILENAME -------------- P:\2008\2008014\KYPipe\Red_Hill.DT2
TABULATED OUTPUT FILENAME -------- P:\2008\2008014\KYPipe\Red_Hill.OT2
POSTPROCESSOR RESULTS FILENAME --- P:\2008\2008014\KYPipe\Red_Hill.RS2

****
S U M M A R Y   O F   O R I G I N A L   D A T A
****

U N I T S   S P E C I F I E D

FLOWRATE .... = gallons/minute
HEAD (HGL) .... = feet
PRESSURE .... = psig

P I P E L I N E   D A T A

STATUS CODE: XX -CLOSED PIPE CV -CHECK VALVE

P I P E N A M E	NODE NAMES #1	#2	LENGTH (ft)	DIAMETER (in)	ROUGHNESS COEFF.	MINOR LOSS COEFF.
P-1	R-1	I-Pump-4	108.84	16.00	130.0000	4.30
P-2	R-1	I-Pump-3	108.84	16.00	130.0000	4.30
P-3	R-1	I-Pump-2	108.84	16.00	130.0000	4.30
P-4	R-1	I-Pump-1	108.84	16.00	130.0000	4.30
P-5	O-Pump-4	N-1	11.59	16.00	130.0000	4.62
P-6	O-Pump-3	N-2	11.59	16.00	130.0000	4.62
P-7	O-Pump-2	N-3	11.59	16.00	130.0000	4.62
P-8	O-Pump-1	N-4	11.59	16.00	130.0000	4.62
P-9	N-1	N-2	8.00	16.00	130.0000	0.25
P-10	N-2	N-3	8.00	18.00	130.0000	0.25
P-11	N-3	N-4	8.00	20.00	130.0000	0.25
P-12	N-4	N-5	3.67	24.00	130.0000	1.80
P-13	N-5	N-6	17.33	30.00	130.0000	2.05
P-14	N-6	N-7	200.00	30.00	130.0000	2.40
P-15	N-7	N-8	130.00	30.00	130.0000	0.22
P-16	N-8	N-9	670.00	30.00	130.0000	0.00
P-17	N-9	N-10	476.00	30.00	130.0000	0.15
P-18	N-10	N-11	519.00	30.00	130.0000	0.00
P-19	N-11	T-2	750.00	30.00	130.0000	4.83

P U M P/L O S S   E L E M E N T   D A T A

THERE IS A DEVICE AT NODE Pump-1 DESCRIBED BY THE FOLLOWING DATA: (ID= 2)

HEAD (ft)	FLOWRATE (gpm)	EFFICIENCY (%)
724.00	0.00	75.00 (Default)
660.00	1000.00	75.00 (Default)
604.00	2000.00	75.00 (Default)
552.00	3200.00	75.00 (Default)
516.00	4250.00	75.00 (Default)
498.00	5200.00	75.00 (Default)
476.00	5900.00	75.00 (Default)
464.00	6150.00	75.00 (Default)
388.00	7450.00	75.00 (Default)
328.00	8200.00	75.00 (Default)

288.00 8680.00 75.00 (Default)

THERE IS A DEVICE AT NODE Pump-2 ....> (ID= 2)

THERE IS A DEVICE AT NODE Pump-3 ....> (ID= 2)

THERE IS A DEVICE AT NODE Pump-4 ....> (ID= 2)

N O D E   D A T A

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	JUNCTION ELEVATION (ft)	EXTERNAL GRADE (ft)
N-1		0.00	0.00	
N-2		0.00	0.00	
N-3		0.00	0.00	
N-4		0.00	0.00	
N-5		0.00	0.00	
N-6		0.00	0.00	
N-7		0.00	0.00	
N-8		0.00	0.00	
N-9		0.00	0.00	
N-10		0.00	0.00	
N-11		0.00	0.00	
I-Pump-1		0.00	0.00	
I-Pump-2		0.00	0.00	
I-Pump-3		0.00	0.00	
I-Pump-4		0.00	0.00	
R-1		----	-10.00	20.00
T-2		----	420.00	462.00
O-Pump-4		0.00	0.00	
O-Pump-3		0.00	0.00	
O-Pump-2		0.00	0.00	
O-Pump-1		0.00	0.00	

O U T P U T   O P T I O N   D A T A

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT
MAXIMUM AND MINIMUM PRESSURES = 1
MAXIMUM AND MINIMUM VELOCITIES = 5
MAXIMUM AND MINIMUM HEAD LOSS/1000 = 5

S Y S T E M   C O N F I G U R A T I O N

NUMBER OF PIPES ....(p) = 19
NUMBER OF END NODES ....(j) = 15
NUMBER OF PRIMARY LOOPS ....(l) = 3
NUMBER OF SUPPLY NODES ....(f) = 2
NUMBER OF SUPPLY ZONES ....(z) = 1

==
Case: 0

RESULTS OBTAINED AFTER 4 TRIALS: ACCURACY = 0.00411

S I M U L A T I O N   D E S C R I P T I O N   (L A B E L)

P I P E L I N E   R E S U L T S

STATUS CODE: XX -CLOSED PIPE CV -CHECK VALVE

P I P E NODE NUMBERS FLOWRATE HEAD MINOR LINE HL+ML/ HL/

N A M E	#1	#2	(gpm)	LOSS (ft)	LOSS (ft)	VELO. (ft/s)	1000 (ft/ft)	1000 (ft/ft)
P-1	R-1	I-Pump-4	5958.56	1.85	6.03	9.51	72.48	17.03
P-2	R-1	I-Pump-3	5968.05	1.86	6.05	9.52	72.70	17.08
P-3	R-1	I-Pump-2	0.00	0.00	0.00	0.00	0.00	0.00
P-4	R-1	I-Pump-1	0.00	0.00	0.00	0.00	0.00	0.00
P-5	O-Pump-4	N-1	5958.56	0.20	6.48	9.51	576.46	17.03
P-6	O-Pump-3	N-2	5968.05	0.20	6.50	9.52	578.30	17.08
P-7	O-Pump-2	N-3	0.00	0.00	0.00	0.00	0.00	0.00
P-8	O-Pump-1	N-4	0.00	0.00	0.00	0.00	0.00	0.00
P-9	N-1	N-2	5958.56	0.14	0.35	9.51	60.89	17.03
P-10	N-2	N-3	11926.62	0.28	0.88	15.04	144.39	34.70
P-11	N-3	N-4	11926.62	0.17	0.58	12.18	92.74	20.77
P-12	N-4	N-5	11926.62	0.03	2.00	8.46	553.28	8.55
P-13	N-5	N-6	11926.62	0.05	0.93	5.41	56.70	2.88
P-14	N-6	N-7	11926.62	0.58	1.09	5.41	8.34	2.88
P-15	N-7	N-8	11926.62	0.37	0.10	5.41	3.65	2.88
P-16	N-8	N-9	11926.62	1.93	0.00	5.41	2.88	2.88
P-17	N-9	N-10	11926.62	1.37	0.07	5.41	3.03	2.88
P-18	N-10	N-11	11926.62	1.50	0.00	5.41	2.88	2.88
P-19	N-11	T-2	11926.62	2.16	2.20	5.41	5.81	2.88

P U M P/L O S S   E L E M E N T   R E S U L T S

NAME	FLOWRATE (gpm)	INLET HEAD (ft)	OUTLET HEAD (ft)	PUMP HEAD (ft)	EFFIC-ENCY (%)	USEFUL POWER (Hp)	INCREMTL COST ($)	TOTAL COST ($)	#PUMPS PARALLEL	#PUMPS SERIES	NPSH Avail. (ft)
Device "Pump-1" is closed											
Device "Pump-2" is closed											
Pump-3	5968.05	12.09	484.98	472.9	----	-----	---	----	**	**	43.9
Pump-4	5958.56	12.11	485.44	473.3	----	-----	---	----	**	**	43.9

N O D E   R E S U L T S

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	HYDRAULIC GRADE (ft)	NODE ELEVATION (ft)	PRESSURE HEAD (ft)	NODE PRESSURE (psi)
N-1		0.00	478.76			
N-2		0.00	478.27			
N-3		0.00	477.12			
N-4		0.00	476.38			
N-5		0.00	474.35			
N-6		0.00	473.37			
N-7		0.00	471.70			
N-8		0.00	471.23			
N-9		0.00	469.30			
N-10		0.00	467.86			
N-11		0.00	466.36			
I-Pump-1		0.00	20.00			
I-Pump-2		0.00	20.00			
I-Pump-3		0.00	12.09			
I-Pump-4		0.00	12.11			
R-1		----	20.00	-10.00	30.00	13.00
T-2		----	462.00	420.00	42.00	18.20
O-Pump-4		0.00	485.44			
O-Pump-3		0.00	484.98			
O-Pump-2		0.00	477.12			
O-Pump-1		0.00	476.38			

M A X I M U M   A N D   M I N I M U M   V A L U E S

P R E S S U R E S

JUNCTION NUMBER	MAXIMUM PRESSURES (psi)	JUNCTION NUMBER	MINIMUM PRESSURES (psi)

T-2	18.20	R-1	13.00

V E L O C I T I E S

PIPE NUMBER	MAXIMUM VELOCITY (ft/s)	PIPE NUMBER	MINIMUM VELOCITY (ft/s)
P-10	15.04	P-13	5.41
P-11	12.18	P-14	5.41
P-2	9.52	P-15	5.41
P-6	9.52	P-16	5.41
P-1	9.51	P-17	5.41

H L + M L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL+ML/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL+ML/1000 (ft/ft)
P-6	578.30	P-16	2.88
P-5	576.46	P-18	2.88
P-12	553.28	P-17	3.03
P-10	144.39	P-15	3.65
P-11	92.74	P-19	5.81

H L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL/1000 (ft/ft)
P-10	34.70	P-13	2.88
P-11	20.77	P-16	2.88
P-2	17.08	P-15	2.88
P-6	17.08	P-17	2.88
P-1	17.03	P-18	2.88

S U M M A R Y   O F   I N F L O W S   A N D   O U T F L O W S

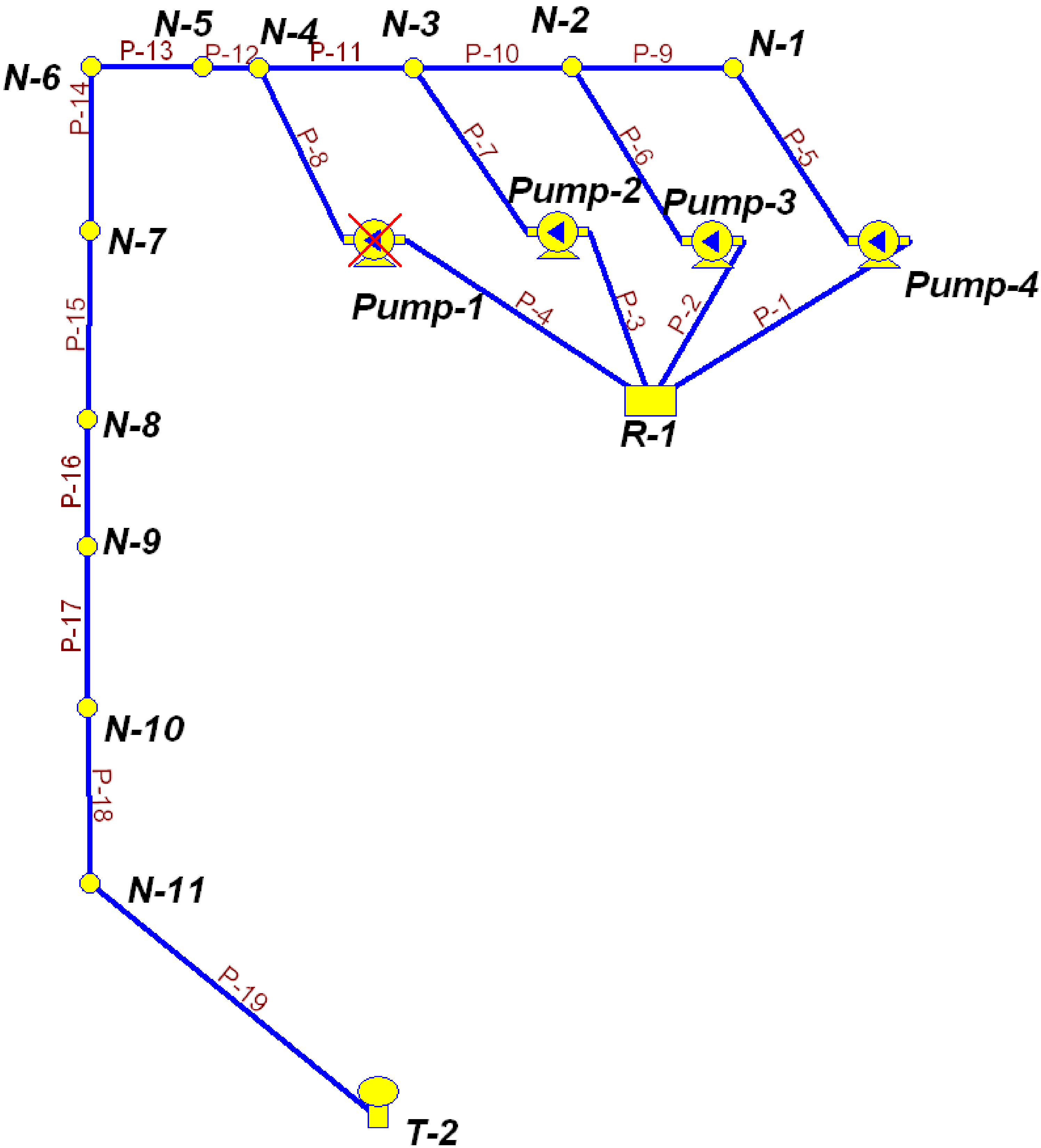
(+) INFLOWS INTO THE SYSTEM FROM SUPPLY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO SUPPLY NODES

NODE NAME	FLOWRATE (gpm)	NODE TITLE
R-1	11926.62	
T-2	-11926.62	

NET SYSTEM INFLOW = 11926.62
NET SYSTEM OUTFLOW = -11926.62
NET SYSTEM DEMAND = 0.00

***** HYDRAULIC ANALYSIS COMPLETED *****

Red Hill Water Treatment - Alt 3 - New Pumps



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* * * * * * * * * * *   K Y P I P E 4   * * * * * * * * * * *
*                                                           *
*              Pipe Network Modeling Software               *
*                                                           *
*               Copyrighted by KYPIPE LLC                   *
*                 Version 4 - April 2008                    *
*                                                           *
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Date & Time: Mon Jul 20 15:26:56 2009

INPUT DATA FILENAME -------------- P:\2008\2008014\KYPipe\Red_Hill.DT2
TABULATED OUTPUT FILENAME -------- P:\2008\2008014\KYPipe\Red_Hill.OT2
POSTPROCESSOR RESULTS FILENAME --- P:\2008\2008014\KYPipe\Red_Hill.RS2

****
S U M M A R Y   O F   O R I G I N A L   D A T A
****

U N I T S   S P E C I F I E D

FLOWRATE .... = gallons/minute
HEAD (HGL) .... = feet
PRESSURE .... = psig

P I P E L I N E   D A T A

STATUS CODE: XX -CLOSED PIPE CV -CHECK VALVE

P I P E N A M E	NODE NAMES #1	#2	LENGTH (ft)	DIAMETER (in)	ROUGHNESS COEFF.	MINOR LOSS COEFF.
P-1	R-1	I-Pump-4	108.84	16.00	130.0000	4.30
P-2	R-1	I-Pump-3	108.84	16.00	130.0000	4.30
P-3	R-1	I-Pump-2	108.84	16.00	130.0000	4.30
P-4	R-1	I-Pump-1	108.84	16.00	130.0000	4.30
P-5	O-Pump-4	N-1	11.59	16.00	130.0000	4.62
P-6	O-Pump-3	N-2	11.59	16.00	130.0000	4.62
P-7	O-Pump-2	N-3	11.59	16.00	130.0000	4.62
P-8	O-Pump-1	N-4	11.59	16.00	130.0000	4.62
P-9	N-1	N-2	8.00	16.00	130.0000	0.25
P-10	N-2	N-3	8.00	18.00	130.0000	0.25
P-11	N-3	N-4	8.00	20.00	130.0000	0.25
P-12	N-4	N-5	3.67	24.00	130.0000	1.80
P-13	N-5	N-6	17.33	30.00	130.0000	2.05
P-14	N-6	N-7	200.00	30.00	130.0000	2.40
P-15	N-7	N-8	130.00	30.00	130.0000	0.22
P-16	N-8	N-9	670.00	30.00	130.0000	0.00
P-17	N-9	N-10	476.00	30.00	130.0000	0.15
P-18	N-10	N-11	519.00	30.00	130.0000	0.00
P-19	N-11	T-2	3168.00	30.00	130.0000	4.83

P U M P/L O S S   E L E M E N T   D A T A

THERE IS A DEVICE AT NODE Pump-1 DESCRIBED BY THE FOLLOWING DATA: (ID= 2)

HEAD (ft)	FLOWRATE (gpm)	EFFICIENCY (%)
905.00	0.00	75.00 (Default)
825.00	1000.00	75.00 (Default)
755.00	2000.00	75.00 (Default)
690.00	3200.00	75.00 (Default)
645.00	4250.00	75.00 (Default)
622.50	5200.00	75.00 (Default)
595.00	5900.00	75.00 (Default)
580.00	6150.00	75.00 (Default)
485.00	7450.00	75.00 (Default)
410.00	8200.00	75.00 (Default)

360.00 8680.00 75.00 (Default)

THERE IS A DEVICE AT NODE Pump-2 ....> (ID= 2)

THERE IS A DEVICE AT NODE Pump-3 ....> (ID= 2)

THERE IS A DEVICE AT NODE Pump-4 ....> (ID= 2)

N O D E D A T A

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	JUNCTION ELEVATION (ft)	EXTERNAL GRADE (ft)
N-1		0.00	0.00	
N-2		0.00	0.00	
N-3		0.00	0.00	
N-4		0.00	0.00	
N-5		0.00	0.00	
N-6		0.00	0.00	
N-7		0.00	0.00	
N-8		0.00	0.00	
N-9		0.00	0.00	
N-10		0.00	0.00	
N-11		0.00	0.00	
I-Pump-1		0.00	0.00	
I-Pump-2		0.00	0.00	
I-Pump-3		0.00	0.00	
I-Pump-4		0.00	0.00	
R-1		----	-10.00	16.00
T-2		----	590.00	624.00
O-Pump-4		0.00	0.00	
O-Pump-3		0.00	0.00	
O-Pump-2		0.00	0.00	
O-Pump-1		0.00	0.00	

O U T P U T O P T I O N D A T A

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT
MAXIMUM AND MINIMUM PRESSURES = 1
MAXIMUM AND MINIMUM VELOCITIES = 5
MAXIMUM AND MINIMUM HEAD LOSS/1000 = 5

S Y S T E M C O N F I G U R A T I O N

NUMBER OF PIPES ....(p) = 19
NUMBER OF END NODES ....(j) = 15
NUMBER OF PRIMARY LOOPS ....(l) = 3
NUMBER OF SUPPLY NODES ....(f) = 2
NUMBER OF SUPPLY ZONES ....(z) = 1

==

Case: 0

RESULTS OBTAINED AFTER 3 TRIALS: ACCURACY = 0.00093

S I M U L A T I O N D E S C R I P T I O N (L A B E L)

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE CV -CHECK VALVE

P I P E NODE NUMBERS FLOWRATE HEAD MINOR LINE HL+ML/ HL/

N A M E	#1	#2	(gpm)	LOSS (ft)	LOSS (ft)	VELO. (ft/s)	1000 (ft/ft)	1000 (ft/ft)
P-1	R-1	I-Pump-4	4797.66	1.24	3.91	7.66	47.35	11.40
P-2	R-1	I-Pump-3	4802.09	1.24	3.92	7.66	47.43	11.42
P-3	R-1	I-Pump-2	4812.55	1.25	3.94	7.68	47.64	11.47
P-4	R-1	I-Pump-1	0.00	0.00	0.00	0.00	0.00	0.00
P-5	O-Pump-4	N-1	4797.66	0.13	4.20	7.66	374.08	11.40
P-6	O-Pump-3	N-2	4802.09	0.13	4.21	7.66	374.77	11.42
P-7	O-Pump-2	N-3	4812.55	0.13	4.23	7.68	376.40	11.47
P-8	O-Pump-1	N-4	0.00	0.00	0.00	0.00	0.00	0.00
P-9	N-1	N-2	4797.66	0.09	0.23	7.66	39.83	11.40
P-10	N-2	N-3	9599.75	0.19	0.57	12.10	94.28	23.21
P-11	N-3	N-4	14412.30	0.24	0.84	14.72	134.59	29.49
P-12	N-4	N-5	14412.30	0.04	2.92	10.22	807.59	12.14
P-13	N-5	N-6	14412.30	0.07	1.36	6.54	82.68	4.09
P-14	N-6	N-7	14412.30	0.82	1.59	6.54	12.07	4.09
P-15	N-7	N-8	14412.30	0.53	0.15	6.54	5.22	4.09
P-16	N-8	N-9	14412.30	2.74	0.00	6.54	4.09	4.09
P-17	N-9	N-10	14412.30	1.95	0.10	6.54	4.30	4.09
P-18	N-10	N-11	14412.30	2.12	0.00	6.54	4.09	4.09
P-19	N-11	T-2	14412.30	12.97	3.21	6.54	5.11	4.09

P U M P/L O S S   E L E M E N T   R E S U L T S

NAME	FLOWRATE (gpm)	INLET HEAD (ft)	OUTLET HEAD (ft)	PUMP HEAD (ft)	EFFIC-ENCY (%)	USEFUL POWER (Hp)	INCREMTL COST ($)	TOTAL COST ($)	#PUMPS PARALLEL	#PUMPS SERIES	NPSH Avail. (ft)
Device "Pump-1" is closed											
Pump-2	4812.55	10.82	645.27	634.5	----	-----	---	----	**	**	43.1
Pump-3	4802.09	10.84	645.58	634.7	----	-----	---	----	**	**	43.1
Pump-4	4797.66	10.85	645.70	634.9	----	-----	---	----	**	**	43.1

N O D E   R E S U L T S

NODE NAME	NODE TITLE	EXTERNAL DEMAND (gpm)	HYDRAULIC GRADE (ft)	NODE ELEVATION (ft)	PRESSURE HEAD (ft)	NODE PRESSURE (psi)
N-1		0.00	641.37			
N-2		0.00	641.23			
N-3		0.00	640.91			
N-4		0.00	639.83			
N-5		0.00	636.87			
N-6		0.00	635.43			
N-7		0.00	647.77			
N-8		0.00	647.09			
N-9		0.00	644.35			
N-10		0.00	642.30			
N-11		0.00	640.18			
I-Pump-1		0.00	16.00			
I-Pump-2		0.00	10.82			
I-Pump-3		0.00	10.84			
I-Pump-4		0.00	10.85			
R-1		----	16.00	-10.00	26.00	11.27
T-2		----	624.00	590.00	34.00	14.73
O-Pump-4		0.00	645.70			
O-Pump-3		0.00	645.58			
O-Pump-2		0.00	645.27			
O-Pump-1		0.00	639.83			

M A X I M U M   A N D   M I N I M U M   V A L U E S

P R E S S U R E S

JUNCTION NUMBER	MAXIMUM PRESSURES (psi)	JUNCTION NUMBER	MINIMUM PRESSURES (psi)

T-2	14.73	R-1	11.27

V E L O C I T I E S

PIPE NUMBER	MAXIMUM VELOCITY (ft/s)	PIPE NUMBER	MINIMUM VELOCITY (ft/s)
P-11	14.72	P-13	6.54
P-10	12.10	P-14	6.54
P-12	10.22	P-15	6.54
P-3	7.68	P-16	6.54
P-7	7.68	P-17	6.54

H L + M L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL+ML/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL+ML/1000 (ft/ft)
P-12	807.59	P-16	4.09
P-7	376.40	P-18	4.09
P-6	374.77	P-17	4.30
P-5	374.08	P-19	5.11
P-11	134.59	P-15	5.22

H L / 1 0 0 0

PIPE NUMBER	MAXIMUM HL/1000 (ft/ft)	PIPE NUMBER	MINIMUM HL/1000 (ft/ft)
P-11	29.49	P-13	4.09
P-10	23.21	P-17	4.09
P-12	12.14	P-14	4.09
P-3	11.47	P-15	4.09
P-7	11.47	P-16	4.09

S U M M A R Y   O F   I N F L O W S   A N D   O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM SUPPLY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO SUPPLY NODES

NODE NAME	FLOWRATE (gpm)	NODE TITLE
R-1	14412.30	
T-2	-14412.30	

NET SYSTEM INFLOW = 14412.30
NET SYSTEM OUTFLOW = -14412.30
NET SYSTEM DEMAND = 0.00

***** HYDRAULIC ANALYSIS COMPLETED *****

Appendix E

References

e) Freezing Point (maximum) -22 degrees F (-30 degrees C)

2.3.3.2 Special Precautions for Kerosene. Design separate systems for kerosene to avoid discoloration caused by contamination. Provide a design that precludes disposing of kerosene into storm or sanitary sewers.

2.3.4 Diesel Fuels

2.3.4.1 Physical Properties of Diesel Fuels

	Automotive DF-2 [F-54]	Diesel Fuel Marine [F-76]
(a) Relative Density API Gravity, °API Specific Gravity	 40 to 34 0.825 to 0.855	 39 to 33 0.830 to 0.860
(b) Reid Vapor Pressure at 100 °F (38 °C), psia (kPa)	0 (0)	0 (0)
(c) Flash Point, °F (°C)	131 (55)	140 (60)
(d) Viscosity at 104 °F (40 °C) ft^2/s (cSt)	2 to 4.4 x 10^{-5} (1.9 to 4.1)	1.8 to 4.6 x 10^{-5} (1.7 to 4.3)
(e) Pour Point, °F (°C)	10 (-12)	20 (-7)

Notes: JP-8 is currently used as arctic grade diesel fuel (DFA) in the Arctic and Antarctic for heating fuel. The gross heating value of JP-8 is 18,400 Btu/lb (42 800 kJ/kg).

DF-1, winter grade diesel fuel, has a flash point of 100 degrees F (38 degrees C) and a viscosity of 1.4 to 2.6 x 10^{-5} ft^2/s (1.3 to 2.4 cSt) at 104 degrees F (40 degrees C).

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Although JP-5 does have a high flash point (140°F minimum) when manufactured, if it is mixed with other fuels that have a lower flash point, the liquid becomes unsafe. Even with its high flash point, JP-5 is highly flammable on rags and clothing, which act as a wick.

JP-5 is also an acceptable substitute for fuel, naval distillate, F-76 (commonly known as DFM), for use in diesels, gas turbines, and boilers.

JP-4 DESCRIPTION

JP-4 (NATO Code Number F-40) is a wide-cut gasoline-type jet fuel having a low flash point, typically below)0°F (-17.8°C). It is used by the Air Force, Army, and some Navy shore stations. It is **volatile, flammable, and dangerous.** JP-4 mixed with JP-5 will lower the JP-5 flash point to an unacceptable level for shipboard use.

JP-8 DESCRIPTION

JP-8 (NATO Code Number F-34) is a kerosene-type jet fuel having a flash point of 100°F (37.8°C). It is used by the Air Force in Europe and the British Isles, rather than JP-4. JP-8 mixed with JP-5 also will lower the flash point of the JP-5 to an unacceptable level for shipboard use.

VOLATILITY

The volatility of a petroleum fuel is usually measured in terms of vapor pressure and distillation. The vapor pressure indicates the tendency toward vaporization at specific temperatures, while distillation provides a measure of the extent to which vaporization proceeds at a series of temperatures.

Vapor pressure is measured in a Reid vapor pressure test bomb. In the test, one volume of fuel and four volumes of air are contained in a sealed bomb fitted with a pressure gage. The container and fuel are heated to 100°F, shaken, and the pressure read on the gage. The pressure shown on the gage is known as the Reid vapor pressure (RVP) and is expressed in pounds per square inch (psi).

The measurement for volatility by distillation is done in a standard distillation apparatus. The fuel in this test is heated to given temperatures with an amount of fuel boiled off as each temperature is measured. The military specification for the fuel gives these temperatures and the percentages of the fuel allowed to boil off to meet the desired standard.

Any fuel must vaporize and the vapor be mixed in a given percentage of air for it to burn or explode. For gasoline vapors in air, the limits are approximately a minimum of 1 percent and a maximum of 6 percent by volume. other types of fuel vapors may have different limits.

Volatility is an important factor in the proper operation of internal-combustion piston engines. In a piston engine, the fuel must vaporize and be mixed with a correct volume of air to bum and deliver power. If part of the fuel does not vaporize, it is wasted. Furthermore, it can damage the engine by washing the lubricant from the engine cylinder walls, which causes rapid wear to the piston rings and cylinder walls.

Military jet fuels in use at the present by the Navy include JP-4, which has a vapor pressure of 2 to 3 psi. and JP-5, which has no specification for vapor pressure. The vapor pressure for JP-5 is almost 0 psi at normal room temperatures and at standard atmospheric pressure.

Gasoline has a very strong tendency to vaporize and, as a result, always has considerable vapors mixed with the air over the surface of the liquid. In fact, in a closed tank at sea level with temperatures approximately 10°F or higher, so much fuel vapor is given off by gasoline that the fuel-air mixture is too rich to burn. When fuel is in contact with air, the fuel continues to evaporate until the air is saturated.

The amount of fuel vapor in the air above a fuel can never be greater than the saturation value. Of course, it takes time to saturate the air with fuel vapor, so the actual percentage of fuel vapor may be considerably below the saturation point, especially if the fuel container is open to air circulation.

JP-5 fuel does not give off enough vapor to be explosive until it is heated considerably above 100°F. However, if the JP-5 fuel is contaminated with even a small amount of gasoline or, more likely, JP-4, the amount of vapor given off increases to the point where it is in the flammable range at a much lower temperature. At room temperatures, 0.1 percent gasoline or JP-4 in JP-5 results in a fuel that is unsafe to store aboard ship since it fails the flash point requirement for unprotected storage.

Because of the range of its vapor pressure, grade JP-4 forms explosive vapors from minus 10°F to plus 80°F, its normal storage and handling temperatures. **This means that the space above the liquid almost always contains an explosive mixture.**

Table 1: Typical Equipment Life Expectancy

Equipment	Life Expectancy in Years
Source of supply	
Intake Structures	35 – 45
Wells and Springs	25 – 35
Galleries and Tunnels	30 – 40
Transmission mains	35 – 40
Pumping Plants	
Structures	30 – 60
Pumping Equipment	10 – 15
Treatment Plants	
Structures	30 – 60
Equipment	10 – 15
Chlorination Equipment	10 – 15
Transmission/Distribution	
Structures	30 – 60
Reservoirs and Tanks	30 – 60
Mains & Distribution Pipes	35 – 40
Services	30 – 50
Valves	35 – 40
Backflow Prevention Valves	35 – 40
Blow-off valves	35 – 40
Meters	10 – 15
Hydrants	40 – 60
General Plant	
Structures	30 – 40
Electrical Systems	7 – 10
Equipment	10 – 15
Transportation Equipment	10
Computers	5
Stores equipment	10
Lab/Monitoring Equipment	5 – 7
Tools and Shop Equipment	10 – 15
Landscaping/Grading	40 – 60
Power operated equipment	10 – 15
Communications equipment	10

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